Standardizing the southern Gulf of St. Lawrence Bottom-Trawl Survey Time Series: Adjusting for Changes in Research Vessel, Gear and Survey Protocol

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ABSTRACT

Bottom-trawl surveys have been conducted annually in the southern Gulf of St. Lawrence during the month of September since 1971. These surveys provide a time series of information on the abundance, size-composition and distribution of more than 70 species of marine and diadromous fish and over 40 marine invertebrate taxa. However, most research activities utilizing these data are contingent on continuity of the time series for each taxon. This means avoiding or correcting for any systematic changes in catchability of these taxa to the survey. During the 33 year history of this survey there have been changes in sampling gear and research vessels, as well as changes in the time of day in which scientific fishing took place. These are all factors that are known to affect catchability and for which corrections should be made to ensure inter-annual comparability of catches. In this report we document such corrections for changes in catchability and also provide a summary of other corrections or considerations that should be taken into account when analysing the southern Gulf of St. Lawrence survey data.

RÉSUMÉ

Des relevés au chalut de fond on étés effectués tous les mois de septembre depuis 1971 dans le sud du golfe du Saint-Laurent. Ces relevés fournissent une série temporelle d'information sur l'abondance, la distribution géographique et la répartition des tailles pour plus de soixante-dix espèces de poissons marins et diadromes, ainsi que pour au de las de quarante groupes d'invertébrés marins. Cependant, toutes activités de recherche s'appuyant sur ces donnés dépendent d'une continuité des séries temporelles pour chaque espèce. On doit donc éviter ou corriger tous les instances où la capturabilité d'une espèce par le relevé a changée de façon systématique. Au cours des 33 ans de relevé dans le sud du Golfe il y a eu des changements dans les engins de pêche et le navires utilisés, ainsi que dans le cycle journalier de l'échantillonnage. Ce sont tous des facteurs qui sont reconnus comme affectant potentiellement la capturabilité des espèces. Des corrections doivent donc être apportées aux donnés du relevé afin d'assurer une comparabilité interannuelle des prises. Le présent rapport sert à documenter toutes corrections de ce genre pour les donnés provenant du relevé de septembre du sud du Golfe du Saint-Laurent. Nous incluons aussi un résumé de toutes autres facteurs qui devraient être pris en considération en analysant ces donnés.

1. INTRODUCTION

Bottom-trawl surveys have been conducted annually in the southern Gulf of St. Lawrence (NAFO div. 4T) during the month of September since 1971 (for details see Hurlbut and Clay 1990). These surveys provide a time series of information on the abundance, size-composition and distribution of over 70 marine and diadromous fish species and over 40 marine invertebrate taxa (Benoît et al. 2003a, c). This information is the cornerstone for the majority of the stock assessments of commercially important marine fishes in the southern Gulf. It has also been crucial in assessing the general status of all fishes captured in the survey as part of the Species-at-Risk mandate of the Department of Fisheries and Oceans (DFO) (Benoît et al. 2003a) and will be invaluable in understanding the changes in the structure and function of the ecosystem as a whole. All of these research activities are contingent upon the continuity of the time series for each species. Survey timing (i.e., season), area sampled, time of day in which fishing takes place, and the research vessel and gear used are all known to affect either or both the availability of organisms to the gear and/or their catchability (e.g., Benoît and Swain 2003; Pelletier 1998; Nielsen 1994). A change in catchability resulting from modifications in one or more of these factors could, for example, incorrectly be interpreted as a change in resource abundance.

With the exception of the addition of three inshore strata (401, 402 and 403) in 1984 (Fig. 1a), both survey timing and area have been kept constant since 1971 in the September survey. (Note that survey series that include strata 401-403 are never extended prior to 1984 to ensure consistency of the data.). However, changes in survey vessel, fishing gear and the time of day of fishing have occurred (see section 1.1 for details), and consequently corrections may be required to maintain consistent time series for many species.

The primary purpose of this report is to document all of the species-specific corrections that should be applied to the September survey data. We begin by summarizing correction factors calculated to account for species-specific diel differences in catchability (Benoît and Swain 2003). Applying these factors where necessary, we then recalculate correction factors for differences in fishing efficiency between research vessels and gears (originally presented in Nielsen (1994)). The details of these analyses are presented in this report.

The secondary purpose of this report is to provide additional information about the bottom-trawl surveys of the southern Gulf of St. Lawrence that is necessary for data analysis, but that is not documented in Hurlbut and Clay (1990). Among other things, this includes a summary of major changes that have occurred to the survey protocol since 1971 and a list of sets that were sampled repeatedly during certain surveys and which must be treated carefully when calculating abundance indices.

1.1 Background (General)

Fishing during the September survey was carried out by the *E.E. Prince* from 1971 to 1985 using a Yankee-36 trawl, by the *Lady Hammond* from 1985 to 1991 using a Western IIA trawl and by the CCGS *Alfred Needler* since 1992 also using a Western IIA trawl. Specifications of these vessels and gears can be found in Nielsen (1994) or Hurlbut and Clay (1990). Prior to each vessel/gear change, comparative fishing experiments were conducted to determine the efficiency of the new vessel relative to the one being replaced (see section 1.3 for details). The target fishing procedure in all years was a 30-minute tow at 3.5 knots. Fishing was restricted to daylight hours (07:00-19:00) from 1971 to 1984 but has been conducted 24 hours per day since 1985. Because it is well known that fishing efficiency can vary by time of day (e.g., Casey and Myers 1998; Hjellvik et al. 2002) as a result of species-specific diel behaviours such as vertical migrations, hiding and trawl avoidance, it is necessary to correct survey catches to a standard time of day in order to maintain a consistent time series prior to and after 1985. Benoît and Swain (2003) examined the diel variation in catchability of 51 species of fish and 13 invertebrate taxa from the annual survey. While we refer interested readers to that study for details, we summarise some of the important points in the next section (1.2).

1.2 Diel Variation in Catchability

Benoît and Swain (2003) used two approaches to examine species-specific diel variation in catchability: comparisons based on paired day and night tows, and statistical control of spatiotemporal effects in regular survey data. These analyses were based on generalized linear (Poisson) models, and were conducted separately for data from the *Lady Hammond* and the CCGS *Alfred Needler* to control for possible vessel-dependency in the diel effect. Overall the authors found that the two approaches to the analysis (paired sets vs. statistical control) provided remarkably similar results. Furthermore, species-specific results were consistent between survey time periods when different vessels were used, and were quite comparable to results from studies conducted in other geographic areas. Where sufficient data existed, both length and depth dependencies in diel variation in catchability were considered. Several cases of the former and a few of the latter were found. All of the species- and vessel-specific correction factors (β_d) necessary to adjust for these diel effects are summarized in Table 1. Only a summary is provided here so that the present technical report may serve as a compilation of all of the adjustments that should be made to ensure consistency in the southern Gulf of St. Lawrence bottom-trawl survey data. Additional details on the analyses of diel variation in catchability can be found in Benoît and Swain (2003). However, for a small number of species, analyses were conducted as a follow-up to Benoît and Swain (2003) and are presented in this report.

When diel differences in catchability (relative number of fish captured) were evident, catchability was usually greater at night than in day for groundfish species. In these cases, the probability of catching any fish (i.e., the probability of non-zero catches) was also often greater at night than in day. Thus, Benoît and Swain (2003) recommended

converting night-time catches to daytime equivalents. This has the added benefit that the data from 1971-1984 do not need to be corrected. This is the approach that we have taken here prior to calculating correction factors for changes in vessel/gear efficiency based on comparative fishing experiments (see sections 1.3 and 2.0).

1.3 Comparative Fishing (1985 & 1992)

Comparative fishing experiments were conducted prior to the vessel/gear change in 1985 and the vessel change in 1992. In 1985, the *Lady Hammond* fished alongside the *E.E. Prince* as it conducted the regular September survey (using regular survey protocols). Paired fishing was conducted during daylight hours, with the vessels fishing in the same direction and as close as was practical. In total, 60 pairs of successful sets were realised (Fig. 1b).

Comparative fishing between the *Lady Hammond* and the CCGS *Alfred Needler* took place during a dedicated survey from August 1-8, 1992. As in the regular annual surveys, fishing locations were selected randomly within strata and standard protocols were adopted. Both vessels fished 24 hours per day. Once again, the vessels fished side-by-side as close as practical, but additionally, the vessel fishing on the port or starboard side was chosen randomly at each station. Paired fishing was successfully conducted at 66 stations during the 1992 comparative fishing experiment (Fig. 1b).

To ensure comparability of the sets in each fishing experiment, Nielsen (1994) calculated paired t-tests on the average depth of tow and the distance towed. For the 1985 experiment, there was no significant difference in the depth towed between vessels, and only a slight difference in the distance towed (*E.E. Prince* towed, on average, 0.155 nautical miles further, $P<0.01$). During the 1992 experiment, the *Alfred Needler* fished on average 1.8 metres deeper ($P<0.001$) and 0.045 nautical miles longer ($P<0.001$) than the *Lady Hammond*. However, the absolute difference in depth was greater than 10 metres in only 2 set pairs (the *Lady Hammond* fishing deeper in one, and the *Alfred Needler* in the other). The difference in distance towed in both 1985 and 1992 is well within the range of the variability experienced annually during the regular surveys.

2. Methods

Analysis of Relative Fishing Efficiency Between Vessels

All catches were standardised to a 1.75 nautical mile tow and converted to daytime equivalents, when necessary (Table 1), prior to the calculation of relative fishing efficiency among vessels. For each comparative fishing experiment, we estimated the fishing efficiency of the vessel being replaced (old vessel) relative to the efficiency of the new vessel using generalized linear models, with a logit link and assuming a binomial error distribution. Such a model evaluates the probability, p_i, that a fish captured in set pair i will have been captured by the old vessel, relative to the probability that the new

vessel will have captured this fish, 1- p_v. If there is no difference in fishing efficiency among the vessels for the given species, then $p_i = 1 - p_i = 0.5$. However, if a difference exists in relative fishing efficiency, 1- p_v must be multiplied by a relative catchability term (b_v) to maintain this equality. This relative catchability term is effectively estimated as the intercept (β_v) of a logistic regression:

$$(1)\ \ln[\frac{p_i}{1-p_i}] = \beta_v; \qquad \text{where } \exp(\beta_v) = b_v$$

The left side of the equation is the logit transformation of p_i = (catch of old vessel / catch of both vessels). This model assumes that individual fish are captured independently, i.e., in the absence of a difference in fishing efficiency among vessels, each fish has an equal probability of being captured by either vessel. This may not always be an appropriate assumption given that fish often aggregate spatially (e.g., schools) and are therefore not captured independently. To allow for such a departure, we used an extra-binomial model in which overdispersion was modelled using a scale parameter ϕ for the variance, estimated using Pearson's χ^2-statistic (see McCullagh and Nelder 1989 for details). This scale parameter, increases the model variance when the data are overdispersed ($\phi>1$) but does not affect the parameter estimates. Model 1 was estimated using a maximum likelihood approach.

The extra-binomial error distribution we have assumed removes the need for prior log-transformation of the data, something that is problematic for zero catches using a log-normal model. However, it is obvious that a null catch for both vessels carries no information about their relative fishing efficiency and it inappropriately inflates the degrees of freedom, making the test more liberal. As a result we only included set pairs in the analysis if the given species was captured by at least one of the vessels (termed "relevant set pairs" hereafter). Relevant set pairs where only one vessel captured the species were used in the estimates of relative fishing efficiency to incorporate possible differences between vessels in the probability of capture (cf. Swain and Poirier 1998). In this regard, our analysis differs from that of Nielsen (1994), who used a multiplicative general linear model excluding all set pairs with one or two null catches.

Significance of the intercept (β_v) in model 1 was initially assessed using analysis of deviance and the F test described by Venables and Ripley (1994, p. 187). Given previous experience with similar models used to estimate diel effects on relative catchability (Casey and Myers 1998; Benoît and Swain 2003), we suspected that these standard significance tests might be overly liberal. As a result, we also tested statistical significance using randomization tests (Manly 1991). One thousand iterations were used with one catch from each set pair being randomly assigned to the old vessel, and the other to the new vessel. For species where there were fewer than 13 relevant set pairs (s), randomizations were limited to all possible permutations of the data (2^s). The standard errors and significance levels stemming from the randomization/permutation analyses are therefore estimated under the null hypothesis of no difference in fishing efficiency among vessels. Statistical significance was given by $(n+1)/N$, where N is the total number of permutations of the data (including the observed permutation) and n is the number of

random permutations that yielded a test statistic equal to or greater than that of the observed permutation.

A large number of statistical tests are made in these analyses. This results in a Type-I error rate that is higher than the nominal level (e.g., when 100 tests are performed, on average five are expected to be significant at the 5% level when the null hypothesis is true). Procedures are available to control the Type-I error rate at a specified level when multiple tests are performed (e.g., Rice 1989). However, these procedures also increase the Type-II error rate (i.e., failure to reject the null hypothesis when it is false). The power of these tests (i.e., the ability to detect a false null hypothesis) is already very low due to small sample size combined with the high variability characteristic of trawl survey catch rates. Thus, we have not adjusted significance levels to control the Type-I error rate given multiple tests.

Where significant differences in fishing efficiency among vessels exist, Swain et al. (1995) recommend adjusting the 1971-1991 catches to be comparable to those by the *Alfred Needler*. In doing so there is no requirement to adjust catches as additional data are collected annually by the current research vessel, the *Alfred Needler*. Adopting this approach, we estimated the relative fishing efficiency of the *E.E. Prince* and *Lady Hammond* in 1985 with catches of the latter converted to be comparable to catches by the *Alfred Needler* (where such a conversion was warranted). Thus, when reporting the results of the comparative fishing experiments in the *Results* section, we always begin with the 1992 comparison, followed by 1985. We also report results of analyses based on unconverted *Lady Hammond* catches so that conversions to a "standard" vessel other than the *Alfred Needler* (e.g., the *Lady Hammond*) are also possible if readers of this report desire to do so.

The relative fishing efficiency of research vessels can be length-dependent (Pelletier 1998), with for example one vessel catching more small individuals of a given species but not more large individuals. Where such an effect is identified, we can correct the historical survey catch data because representative length-frequencies of all finfish species have been recorded as part of the standard survey protocol since 1971 (Hurlbut and Clay 1990). We looked for possible length-dependencies in the relative fishing efficiency between the old and new vessels in two ways. We began by examining the total length-distribution of fish from each vessel's catches to see if the same sizes of individuals from a given species were equally represented. (Note that since the total number of sets for each vessel is identical, the total length frequency should be comparable between vessels.) For each species with sufficient body length variation and sufficient numbers of individuals, we also estimated separate parameters for differences in fishing efficiency between vessels (using model 1) within length intervals (bins). In most cases 3-cm length intervals were used, although this was increased to coarser intervals where data were sparse. The smallest and largest length intervals for each species represented a pooling of all individuals smaller and larger than the designated lengths, respectively. Relationships between fish length and relative fishing efficiency were examined visually by plotting β_r (from model 1) calculated within each length interval (l), against the mid-point of each length interval. There was only a single case

(see results for eelpouts, *Lycodes* sp.) where a relationship was evident from such an analysis and seemed to be best described by a linear model:

$$(2)\ \beta_{v,l} = \alpha_0 + \alpha_1 \cdot \text{midpoint}_l + \varepsilon$$

where α_0 is the intercept, α_1 is the slope and ε is residual error. Although such detailed length-based analyses were conducted for over a dozen species, we do not present these results when the effect was not significant in order to conserve space. Nonetheless, length-frequency plots are presented for all species where a sufficient number and size-range of individuals were captured.

We further tested for possible effects of fishing depth on the relative fishing efficiency of the old and new vessels by adding a covariate for depth to model 1. The randomization procedure described above was used to test the significance of the depth effect. Unfortunately, limited sample size prevented us from considering the interaction between length and depth dependencies on relative vessel fishing efficiency (cf. Benoît and Swain 2003).

The nominal wingspread of the trawl was 35 feet (10.7 m) prior to 1985 (when the Yankee 36 trawl was used) and 41 feet (12.5 m) since then (Western IIa trawl). Catches using the Yankee 36 trawl could be adjusted by the ratio of the wingspreads (41/35) before comparing catches by paired sets. However, as noted by Nielsen (1994), this assumes proportionality between wingspread and catch. If the relationship is not linear or if the actual ratio is not equal to the ratio of the wingspreads (e.g., due to fishing behaviour of the trawls such as herding), then error would be introduced in making such a conversion. The alternative, which we have adopted here, is to compare the paired sets directly, incorporating all differences in fishing efficiency between the vessels in the conversion factors (b_v) (cf. Nielsen 1994; Fanning 1985).

3. RESULTS

The results of analyses of diel variation on catachability and of comparative fishing among vessels are provided species-by-species below (ordered by DFO species codes (Losier and Waite 1989)). We limit our presentation of results to those species where an analysis of relative fishing efficiency was possible for either the 1985 or 1992 comparative experiments (summarized in Tables 2 and 3), or for which a significant diel effect was found by Benoît and Swain (2003) (Table 1). In doing so we provide a compendium of all correction factors that should be applied to the annual survey data.

When presenting the results of the comparative fishing experiments for each taxon, we present biplots of the set-by-set catch of each vessel for both the 1992 and 1985 experiments. For finfish species that were captured in sufficient numbers we also present total length frequencies of the catches. Finally, for all taxa we also present time series of the relative abundance index (1971-2002; survey strata 415-439) in mean numbers·tow^{-1} for fish and mean kg·tow^{-1} for invertebrates. Separate series are presented for uncorrected

catches as well as catches corrected for relative differences in fishing efficiency between vessels.

3.1 Fin fish

3.1.1 Atlantic cod (*Gadus morhua*) - code 10

Benoît and Swain (2003) found only a marginally significant diel effect on catchability of cod for the *Alfred Needler* series. Although there were indications of a slight effect for smaller fish (<20 cm), concurrent consideration of length and depth-dependencies suggested this effect was spurious. As a result of the non-significant effect for the *Lady Hammond* series and only marginally significant effect for the *Alfred Needler* series, no correction for diel variation in catchability is applied for Atlantic cod.

The results of the 1985 and 1992 comparative fishing experiments were examined in detail for cod by Nielsen (1994), and apparent depth-dependent differences in fishing efficiency among vessels were considered further by Swain et al. (1995). As a result we only briefly summarize the findings and refer interested readers to those studies for added detail.

Overall, the *Alfred Needler* caught more cod than the *Lady Hammond* (Fig. 2; Table 2). However their relative efficiency varied significantly with depth (Table 3), with the *Alfred Needler* catching more cod in shallow water and less in deep water (Nielsen 1994). The *Alfred Needler* captured more small cod as compared to the *Lady Hammond* (Fig. 2), however this may largely reflect differences in the spatial (depth) distribution of cod in the southern Gulf of St. Lawrence as a function of age/size (Swain 1993). Nielsen (1994) recommends converting catches of the *Lady Hammond* to be comparable to the *Alfred Needler* as follows:

$$\textit{Needler}\ \text{equiv.} = \textit{Hammond}\ \text{catch} * (\exp(0.491908 - (0.004609 * \text{depth}))) * (\exp(\sigma * 55/108))$$

where, $\sigma = 0.01970883 - (0.00038396 * \text{depth}) + (0.00000278 * \text{depth}^2)$

When this conversion is applied we find a statistically significant difference in the relative fishing efficiency of the *E.E. Prince* and the *Lady Hammond* (Fig. 2; Table 2). This difference was not length- (Fig. 2) nor depth-dependent (Table 3). Catches of the *E.E. Prince* must be multiplied by 1.31 to be comparable to the *Alfred Needler*.

In summary, no adjustments for diel effects are required to produce a standard time series for cod, but catches by the *E. E. Prince* and *Lady Hammond* must be adjusted to be equivalent to those by the *Alfred Needler* using depth-independent and depth-dependent factors, respectively.

3.1.2 White hake (*Urophycis tenuis*) - code 12

Benoît and Swain (2003) found important length-dependencies in the diel variation in catchability of white hake (Table 1). In catches by both the *Lady Hammond* and the *Alfred Needler*, small individuals (<30 cm) were more catchable at night, whereas adult hake (40+ cm) were slightly more catchable during the day or showed no diel variation.

The fishing vessels did not differ significantly in relative fishing efficiency at capturing white hake (Fig. 3; Tables 2 & 3).

No adjustments for the changes in vessel or gear are required for white hake, but we have adjusted night catches to be equivalent to day catches using length-dependent correction factors in order to produce a standard time series.

3.1.3 Silver hake (*Merluccius bilinearis*) - code 14
3.1.4 Pollock (*Pollachius virens*) - code 16

Catches of these species did not vary significantly over the diel cycle (Benoît and Swain 2003), nor did they differ significantly among vessels, although sample sizes were small (Fig. 4; Tables 2 & 3). Thus, no adjustments have been applied to produce standard time series for these species.

3.1.5 Redfish (*Sebastes* sp.) - code 23

No attempts are made to differentiate redfish to species in the southern Gulf of St. Lawrence surveys given their morphological similarity. However, most redfish in the area are either *S. fasciatus* or *S. mentella*.

Catches of redfish did not vary significantly over the diel cycle (Benoît and Swain 2003), nor did they differ significantly among vessels (Fig. 5; Tables 2 & 3). The vessels captured similar sizes of redfish.

Nielsen (1994) had previously found that the *Lady Hammond* captured more redfish than the *E.E. Prince*. Indeed our initial statistical analyses based on analysis of deviance indicated a significant difference in relative fishing efficiency (P=0.023) between these two vessels. However our randomization analysis suggested that that conclusion may be based on overly liberal tests (Table 2). Consequently we have applied no adjustments to construct standard time series for redfish.

3.1.6 Atlantic halibut (*Hippoglossus hippoglossus*) - code 30

Atlantic halibut are more catchable at night by the *Alfred Needler* (Benoît and Swain 2003) (Table 1) but there are insufficient data to test for a diel effect in the *Lady*

Hammond catches (H. Benoît, *unpublished results*). However, given that the diel effect is typically very similar among vessels for many species (see Fig. 3c in Benoît and Swain 2003) we recommend applying the correction factor derived from the *Alfred Needler* series to the *Lady Hammond* catches.

Too few Atlantic halibut were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, night catches by the *Alfred Needler* and the *Lady Hammond* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for Atlantic halibut.

3.1.7 Greenland halibut (*Reinhardtius hippoglossoides*) - code 31

Catches of Greenland halibut did not vary significantly over the diel cycle (Benoît and Swain 2003), nor did they differ significantly among vessels (Fig. 6; Tables 2 & 3). Although the *Lady Hammond* appeared to catch more intermediate sized fishes (30-50 cm) compared to the *E.E. Prince* (Fig. 6), this was true only for two of the seventeen set pairs where Greenland halibut were captured. Thus, no adjustments are required to construct a standard time series for Greenland halibut.

3.1.8 American plaice (*Hippoglossoides platessoides*) - code 40

Benoît and Swain (2003) detected no diel variation in the catchability of American plaice, except at very small sizes (<10 cm). This effect was weak even for small plaice, which were only about 1.1-1.6 times more catchable at night. Furthermore, diel effects did not vary consistently with length between depth zones. Thus, we have not applied adjustments for diel differences in catchability when constructing a standardized time series for American plaice.

The *Alfred Needler* and the *Lady Hammond* did not differ significantly in efficiency when capturing American plaice, with both vessels capturing similar sizes of individuals (Fig. 7; Tables 2 & 3). However, the *E.E. Prince* was less efficient than the *Lady Hammond* at capturing this species. This difference did not depend on fishing depth, but the *Lady Hammond* did seem to be particularly more efficient at capturing intermediate sized (15-30 cm) American plaice. We looked for possible size-dependent differences in efficiency by estimating β_r within 3 cm length classes and plotting these as a function of length (Fig. 8). Although this clearly shows the superior efficiency of the *Lady Hammond* at catching intermediate sized plaice, it does not suggest any continuous length-dependent patterns in relative efficiency. Given this lack of a continuous pattern and the fact that 15-30 cm individuals represent over 75% of regular survey catch numbers for this species (see Benoît et al. 2003a), we recommend applying a length-aggregated correction for differences in vessel fishing efficiency. We have multiplied American plaice catches by the *E.E. Prince* by 1.426 to construct a standardized time series for this species.

3.1.9 Witch flounder (*Glyptocephalus cynoglossus*) - code 41

Benoît and Swain (2003) found that witch flounder were more catchable at night. This effect was most pronounced in shallow water and decreased in magnitude with increasing depth. The slope of the diel effect with depth was very similar for catches from the *Alfred Needler* and from the *Lady Hammond* (see Table 2 in Benoît and Swain 2003). As a result, we combined the catches from the two series to estimate an overall depth-dependent diel effect. Following Benoît and Swain (2003), we used Poisson regression to estimate the diel effect in 50 m depth bins and fit a nonlinear regression to these point estimates to obtain a continuous relationship with depth (Fig. 9; Table 1).

Catches of witch flounder did not differ significantly among vessels (Fig. 10; Tables 2 & 3). The vessels captured similar sizes of individuals. Thus, we have adjusted night catches to be equivalent to day catches using the depth-dependent factor given in Table 1, but have applied no other adjustments to construct a standardized time series for witch flounder.

3.1.10 Yellowtail flounder (*Limanda ferruginea*) - code 42

Benoît and Swain (2003) found very important length-dependencies in the diel variation in catchability of yellowtail flounder (Table 1). In catches by both the *Lady Hammond* and the *Alfred Needler*, the smallest individuals (<12 cm) were almost one hundred times more catchable at night, with the magnitude of this effect decreasing exponentially with increasing body size.

The vessels did not differ significantly in relative fishing efficiency when capturing yellowtail flounder (Fig. 11; Tables 2 & 3). Nielsen (1994) had previously found that the *Lady Hammond* captured more yellowtail flounder than the *E.E. Prince*.
Our analysis of deviance also indicated a significant difference in relative fishing efficiency (P=0.001), but a randomization test failed to identify a significant difference between these two vessels (Table 2). Thus, we have adjusted night catches to be equivalent to day catches using the length-dependent factors given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.11 Winter flounder (*Pseudopleuronectes americanus*) - code 43

Catches of winter flounder did not vary significantly over the diel cycle, though a tendency for catches by the *Alfred Needler* to be greater at night approached significance (Benoît and Swain 2003).

Although the *Alfred Needler* and the *Lady Hammond* captured winter flounder with similar efficiency, the latter vessel was more efficient than the *E.E. Prince* (Fig. 12; Table

2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Winter flounder catches by the *E.E. Prince* should be multiplied by 2.323 to be comparable to those by the *Lady Hammond* and the *Alfred Needler*.

3.1.12 Atlantic wolffish (*Anarhichas lupus*) - code 50

Preliminary analysis of a diel effect on catchability for Atlantic wolffish suggested that the magnitude of the effect was quite comparable for the *Alfred Needler* (β_d=0.699±0.406 (SE)) and the *Lady Hammond* (β_d =0.737±0.399 (SE)), although small sample size limited the power to detect a significant effect for either vessel. Consequently we combined the catches from both vessels to estimate a single relationship, and found that the species was more catchable at night (β_d =0.740±0.288 (SE), P=0.005) (Table 1). Too few Atlantic wolffish were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, night catches by the *Alfred Needler* and the *Lady Hammond* were adjusted to be equivalent to day catches, but no other adjustments were applied to construct standard time series for this species.

3.1.13 Herring (*Clupea harengus*) - code 60

Herring were much more catchable during the day by both the *Lady Hammond* and the *Alfred Needler* (Table 1).

The fishing vessels did not differ significantly in relative fishing efficiency for herring (Fig. 13; Tables 2 & 3). Although the *Alfred Needler* appeared to capture more 18 cm fish and fewer 28-38 cm fish than the *Lady Hammond*, this result was driven by one influential set pair in the case of the former and two pairs for the latter (of 41 relevant pairs). Given that the size of herring catches in the September survey can vary considerably over short temporal and spatial scales (e.g., Hurlbut et al. 2003), we decided not to apply length-dependent adjustment factors that were based on one or two influential sets. Thus, night catches by the *Lady Hammond* and the *Alfred Needler* were adjusted to be equivalent to day catches, but no other adjustments were applied to construct standardized time series for herring.

3.1.14 Gaspereau (*Alosa* sp.) - code 62

No attempts are made to differentiate alewife (*Alosa pseudoharengus)* and blueback herring (*A. aestivalis*) in the September survey, and consequently both fall under the collective name of gaspereau.

Gaspereau were much more catchable during the day for both the *Lady Hammond* and the *Alfred Needler* (Table 1). The fishing vessels did not differ significantly in relative fishing efficiency when capturing gaspereau (Fig. 4; Tables 2 & 3), although too few were captured in 1992 to provide much power to test this hypothesis and a tendency for

the *Lady Hammond* to catch more gaspereau than the *E.E. Prince* approached significance (Table 2). The increase in mean catch rate between 1984 and 1985 is consistent with increased catchability of gaspereau to the *Lady Hammond*, although given the considerable inter-annual fluctuation in catch rates of gaspereau since 1971 this is not strong evidence (Fig. 4). No corrections were applied to construct standardized time series for gaspereau, except for the adjustment of night catches to be equivalent to day catches.

3.1.15 Rainbow smelt (*Osmerus mordax mordax*) - code 63

Rainbow smelt were more catchable during the day for both the *Lady Hammond* and the *Alfred Needler* (Table 1).

The *Alfred Needler* was more efficient than the *Lady Hammond* at capturing rainbow smelt (Fig. 14; Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Rainbow smelt catches by the *Lady Hammond* must be multiplied by 2.187 to be comparable to the *Alfred Needler*. It is important to note however that this relationship is based on a relatively small number of paired sets (10).

The *Lady Hammond* was much more efficient than the *E.E. Prince* at capturing rainbow smelt, although this effect is only statistically significant when the *Lady Hammond* catches are converted to *Needler* equivalents (Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Rainbow smelt catches by the *E.E. Prince* must be multiplied by 6.439 to be comparable to the *Alfred Needler*.

In order to construct standardized time series for rainbow smelt, corrections are necessary to account for diel differences in catchability for the *Alfred Needler* and the *E.E. Prince*, as well as corrections for the vessel changes that occurred in 1985 and 1992.

3.1.16 Capelin (*Mallotus villosus*) - code 64

Capelin were more catchable by the *Alfred Needler* during the day (Table 1). A significant diel difference in catchability was not detected for catches by the *Lady Hammond* (β_d =1.482±1.172 (SE), P=0.262; H. Benoît, *unpublished results*).

The *Alfred Needler* was more efficient than the *Lady Hammond* at capturing capelin (Fig. 15; Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Capelin catches by the *Lady Hammond* must be multiplied by 2.461 to be comparable to the *Alfred Needler*. It is important to note however that this relationship is based on a relatively small number of paired sets (10).

The *Lady Hammond* was more efficient than the *E.E. Prince* at capturing capelin, whether or not its catches are converted to *Needler* equivalents (Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Capelin catches by the *E.E. Prince* must be multiplied by 16.871 to be comparable to the *Alfred Needler*. It is important to note however that this relationship is based on a relatively small number of paired sets (9), although it is clear from Fig. 15 that capelin were much more likely to be caught by the *Lady Hammond* than by the *E.E. Prince*. Furthermore, given the very low abundance of capelin prior to 1990, even such drastic corrections have little impact on the long-term trend (Fig. 15).

3.1.17 Mackerel (*Scomber scombrus*) - code 70

Mackerel were more catchable during the day for both the *Lady Hammond* and the *Alfred Needler* (Table 1). The fishing vessels did not differ significantly in relative fishing efficiency when capturing mackerel (Fig. 4; Tables 2 & 3), although there was a tendency for the *Lady Hammond* to catch more mackerel than the *E.E. Prince*. The increase in catch rate between 1984 and 1985 (Fig. 4) is also consistent with greater catchability of mackerel to the *Lady Hammond* than to the *E.E. Prince*. It is likely that the power of the statistical test applied to the 1985 comparative fishing data was likely very low due to small sample size for mackerel. On the other hand, there is no indication of a break in the time series in 1992, when the fishing vessel changed from the *Lady Hammond* to the *Alfred Needler* (Fig. 4). Except for the adjustment of night catches to be equivalent to day catches, no corrections were applied to construct standardized time series for mackerel, though we acknowledge the possibility of an uncorrected increase in catchability in 1985.

3.1.18 Longfin hake (*Phycis chesteri*) - code 112

Longfin hake are more catchable at night, although the strength of this effect decreases with increasing length (Table 1). This effect was consistent for both the *Lady Hammond* and the *Alfred Needler* so the catches from both vessel series were pooled to increase sample size and estimate a single relationship (Fig. 16).

Too few longfin hake were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, we have adjusted night catches to be equivalent to day catches using the length-dependent factors given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.19 Fourbeard rockling (*Enchelyopus cimbrius*) - code 114

Benoît and Swain (2003) found that fourbeard rockling were more catchable at night, although this effect was most pronounced in shallow waters. Given the relatively small number of fourbeard rockling catches and the fact that their distribution in the southern

Gulf of St. Lawrence is bimodal with respect to depth (Benoît et al. 2003b), we estimated their relative diel catchability in two depth bins, <100m and ≥100m, using Poisson regression (Table 1).

The *Lady Hammond* was more efficient than the *Alfred Needler* at capturing fourbeard rockling (Fig. 16; Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Fourbeard rockling catches by the *Lady Hammond* must be divided by 1.642 to be comparable to the *Alfred Needler*.

Although the *E.E. Prince* and *Lady Hammond* did not differ significantly in their ability to capture fourbeard rockling (Tables 2 & 3), correcting the *Lady Hammond* catches to be like the *Alfred Needler* has the added benefit of reducing the apparent (non-significant) difference in catchability between the *Lady Hammond* and the *E.E. Prince* (Fig. 17).

Thus we have adjusted night catches to be equivalent to day catches using the depth-dependent factors given in Table 1 and have adjusted the catches by the *Lady Hammond* in constructing standardized time series for this species.

3.1.20 Greenland cod (*Gadus ogac*) - code 118

Greenland cod were more catchable by the *Alfred Needler* at night (Table 1). A similar effect could not be detected in catches by the *Lady Hammond*, possibly owing to lower power associated with smaller sample size (Benoît and Swain 2003).

The *Lady Hammond* and the *Alfred Needler* did not differ significantly in relative fishing efficiency when capturing Greenland cod (Fig. 18; Tables 2 & 3). A single Greenland cod was captured during the 1985 comparative fishing. Thus, we have adjusted night catches to be equivalent to day catches for the *Alfred Needler* using the correction factor given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.21 Cunner (*Tautogolabrus adspersus*) - code 122

Cunners were more catchable by the *Alfred Needler* during the day (Table 1). A similar effect could not be detected in catches by the *Lady Hammond*, possibly owing to low power associated with small sample size (Benoît and Swain 2003). Furthermore, too few cunner were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, we have adjusted night catches to be equivalent to day catches for the *Alfred Needler* using the correction factor given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.22 Windowpane (*Scophthalmus aquosus*) - code 143

Windowpane were more catchable at night for both the *Lady Hammond* and the *Alfred Needler* (Table 1). The *E.E. Prince* and the *Lady Hammond* did not differ significantly in relative fishing efficiency when capturing windowpane (Fig. 18; Tables 2 & 3). Few windowpane were captured during the 1992 comparative fishing. Thus, we have adjusted night catches to be equivalent to day catches using the correction factors given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.23 Thorny skate (*Amblyraja radiate*) - code 201

Thorny skate were more catchable at night by both the *Lady Hammond* and the *Alfred Needler*, although the strength of this effect decreases linearly with increasing length (Table 1).

The *Lady Hammond* was more efficient than the *Alfred Needler* at capturing thorny skate (Fig. 19; Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Thorny skate catches by the *Lady Hammond* must be divided by 1.512 to be comparable to the *Alfred Needler*. When this correction is applied, the *E.E. Prince* is found to have also been more efficient at capturing thorny skate as compared to the *Alfred Needler*, although it did not differ in efficiency with the (uncorrected) *Lady Hammond*. Thorny skate catches by the *E.E. Prince* must be divided by 1.465 to be comparable to the (corrected) *Lady Hammond*. The difference in catchability between the *E.E. Prince* and the corrected *Lady Hammond* is only marginally significant (P=0.05), but the application of this correction makes the pattern in thorny skate abundance invariant to whether *Alfred Needler* catches are converted to *Lady Hammond* equivalents (by multiplying by 1.512) or *Lady Hammond* catches are converted to *Alfred Needler* equivalents (by dividing by 1.512).

In constructing standardized time series for this species, night catches must be converted to daytime equivalents using the length-dependent correction factors given in Table 1, and catches by the *E. E. Prince* and *Lady Hammond* must be adjusted to be equivalent to those by the *Alfred Needler*.

3.1.24 Smooth skate (*Malacoraja senta*) - code 202

Smooth skate were more catchable at night by both the *Lady Hammond* and the *Alfred Needler* (Table 1). The fishing vessels did not differ significantly in fishing efficiency when capturing this species, though the power to detect a difference was very low (Fig. 20; Tables 2 & 3). Thus, we have adjusted night catches to be equivalent to day catches using the correction factors given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for smooth skate.

3.1.25 Winter skate (*Leucoraja ocellata*) - code 204

Winter skate were more catchable at night by both the *Lady Hammond* and the *Alfred Needler* (Table 1). This effect varied with skate length in catches by the *Lady Hammond*, with a greater effect at shorter lengths (Benoît and Swain 2003). A similar length-dependency was suggested for catches by the *Alfred Needler*, but in this case the effect of length on diel variation in catchability was not statistically significant, possibly due to the reduced sample size resulting from reduced abundance of large skates in the *Alfred Needler* portion of the time series. However, the length-dependent pattern evident for the *Alfred Needler* did not differ significantly from that of the *Lady Hammond* in a general linear model including a factor for vessels and length as a covariate (vessel factor: $F_{1,20}$=0.49, P=0.492). Consequently we combined the data for both vessels to estimate a single length-dependent adjustment factor for diel differences in catchability (length effect: $F_{1,21}$=5.458, P=0.0006) (Table 1).

The fishing vessels did not differ significantly in relative fishing efficiency when capturing winter skate (Fig. 21; Tables 2 & 3). Thus, in constructing standardized time series for this species, the only adjustment necessary is for night catches to be converted to daytime equivalents using the length-dependent correction factor given in Table 1.

3.1.26 Spiny dogfish (*Squalus acanthias*) - code 220

Spiny dogfish were more catchable by the *Alfred Needler* during the day (Table 1), but equally catchable between day and night by the *Lady Hammond* (Benoît and Swain 2003).

The fishing vessels did not differ significantly in relative fishing efficiency when capturing spiny dogfish (Fig. 22; Tables 2 & 3). Although the *Alfred Needler* appears to catch more small dogfish than the *Lady Hammond*, small sample size precluded testing for a length-dependent difference in efficiency. Thus only an adjustment for diel differences in catchability for catches by the *Alfred Needler* is required in constructing a standardized time series for spiny dogfish.

3.1.27 Atlantic hagfish (*Myxine glutinosa*) - code 241

Hagfish were more catchable by the *Alfred Needler* at night (Table 1). A similar difference could not be detected for catches by the *Lady Hammond*, though sample size was lower for the *Lady Hammond* data (Benoît and Swain 2003).

Too few hagfish were captured during the comparative fishing to assess the relative fishing efficiency of vessels (Fig. 23; Table 2). Thus only an adjustment for diel differences in catchability for catches by the *Alfred Needler* is required in constructing a standardized time series for this species.

3.1.28 Longhorn sculpin (*Myoxocephalus octodecemspinosus*) - code 300

Benoît and Swain (2003) found very important length-dependencies in the diel variation in catchability of longhorn sculpin (Table 1). In catches by both the *Lady Hammond* and the *Alfred Needler*, the smallest individuals (<15 cm) were ten to thirty times more catchable at night, with the magnitude of this effect decreasing exponentially with increasing body size.

The fishing vessels did not differ significantly in relative fishing efficiency when capturing longhorn sculpin (Fig. 24; Tables 2 & 3). Thus, we have adjusted night catches to be equivalent to day catches using the length-dependent factors given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.29 Shorthorn sculpin (*Myoxocephalus scorpius*) - code 301

Shorthorn sculpin were more catchable by the *Alfred Needler* at night (Table 1), but equally catchable day and night by the *Lady Hammond* (Benoît and Swain 2003).

The fishing vessels did not differ significantly in relative fishing efficiency when capturing shorthorn sculpin, although there were very few catches on which to base this determination (Fig. 18; Table 2). Thus only an adjustment for diel differences in catchability for catches by the *Alfred Needler* is required in constructing a standardized time series for this species.

3.1.30 Mailed (moustache) sculpin (*Triglops murrayi*) - code 304

Benoît and Swain (2003) found that mailed sculpin were much more catchable at night. This effect was most pronounced in shallow water and decreased in magnitude with increasing depth. The slope of the diel effect with depth was similar for catches from the *Alfred Needler* and from the *Lady Hammond* (see Table 2 in Benoît and Swain 2003). As a result, we combined the catches from the two series to estimate an overall depth-dependent diel effect. Using a Poisson regression, as was done in Benoît and Swain (2003), we estimated the diel effect in individual 25 m depth bins and fit a nonlinear regression to these point estimates in order to obtain a continuous relationship with depth (Fig. 25; Table 1).

Catches of mailed sculpin did not differ significantly among vessels, although few were captured during the 1985 comparative fishing (Fig. 26; Tables 2 & 3). Thus, we have adjusted night catches to be equivalent to day catches using the depth-dependent factors given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.31 Atlantic hookear sculpin (*Artediellus atlanticus*) - code 880 (formerly coded as 306)

Atlantic hookear sculpins were significantly more catchable at night by the *Alfred Needler* (Table 1). A significant diel difference in catchability was not detected for catches by the *Lady Hammond* (β_d =0.697±0.516 (SE), P=0.139; H. Benoît, *unpublished results*). Too few Atlantic hookear sculpins were captured during the comparative fishing experiments to make any conclusions about the relative fishing efficiency of vessels. Adjusting night catches by the *Alfred Needler* to be like day catches is therefore the only adjustment required to obtain a standardized series for this species.

3.1.32 Unidentified sculpins (Cottidae Family) - code 311/312
3.1.33 Spatulate sculpin (*Icelus spatula*) - code 314
3.1.34 Arctic sculpin (*Myoxocephalus scorpioides*) - code 316

These sculpins were all more catchable at night by the *Alfred Needler* (Table 1). Because they were not captured in the September survey prior to the mid-1990s (Benoît et al. 2003a), adjusting for the diel effect is the only correction that needs to be made to the survey data in order to obtain standardized time series.

3.1.35 Sea raven (Hemitripterus americanus) - code 320

Sea raven were more catchable at night by both the *Lady Hammond* and the *Alfred Needler*, although the strength of this effect decreased linearly with increasing length (Table 1).

The fishing vessels did not differ significantly in relative fishing efficiency when capturing sea raven (Fig. 27; Tables 2 & 3). Thus, we have adjusted night catches to be equivalent to day catches using the length-dependent factors given in Table 1, but have made no adjustments for changes in vessel or gear in constructing standardized time series for this species.

3.1.36 Alligatorfish (*Aspidophoroides monopterygius*) - code 340
3.1.37 Sea poacher (*Leptagonus decagonus*) - code 350

Alligatorfish were more catchable at night by both the *Lady Hammond* and the *Alfred Needler* (Table 1). Sea poacher were more catchable at night by the *Alfred Needler* (Table 1), but a significant diel difference in catchability was not detected for catches by the *Lady Hammond* (β_d =-0.171±0.400 (SE), P=0.650; H. Benoît, *unpublished results*).

There is evidence that these two species may have been confused in historical catches for the southern Gulf of St. Lawrence, based on the length frequency distributions of those catches (Benoît et al. 2003a). Alligatorfish are reported to grow to a length of about 18 cm (Scott and Scott 1988), however there are records of 20-30 cm individuals in the survey database. These fish may be sea poacher, which are known to reach those sizes. It is quite likely that these species were also confused during the 1985 comparative fishing experiment, and possibly during the 1992 experiment. This is suggested not only by discrepancies in the length-frequencies of each species, but also the mutual exclusion in catches (i.e. one vessel catching one species, with the other vessel catching the other species) (Figs. 28 & 29). Although it would be possible to ascribe all larger fish (>18 cm) to the sea poachers with reasonable confidence, there is no way to verify the correct identity of smaller fish. Thus, we performed analyses of the comparative fishing data with catches of both species combined. However, we also present the relative fishing efficiency of the vessels for catches from each species separately, as they were recorded at the time of collection.

The *Lady Hammond* and the *Alfred Needler* were equally efficient at capturing alligatorfish and sea poacher, whether these species were analysed separately or together (Figs. 28 & 29; Tables 2 & 3). The *E.E. Prince* and the *Lady Hammond* were also equally efficient at capturing the species when they are combined together; however the *E.E. Prince* was more efficient at capturing fish originally identified as alligatorfish (Fig. 28; Table 2). One set pair, where the *E.E. Prince* captured over 110 alligatorfish and the *Lady Hammond* captured 16 was very influential. When this pair is removed, the relative catchability (*Prince:Hammond*) changed from 6.7 to 4.9, and remained significant at P=0.001. There is also evidence that this relationship may depend on depth (Table 3). However, applying the correction to the *E.E. Prince* survey catches appears to introduce a break in the time series between pre- and post-1985 (Fig. 28, bottom panel). This may result partly from misidentification of Atlantic sea poachers as alligator fish on the *E.E. Prince* in 1985 but not in earlier years.

Given the uncertainties described above and the result of analyses where the two species were combined, we do not recommend correcting the catches of either alligatorfish or sea poacher for differences in fishing efficiency between vessels. Thus, the only adjustments we have applied in constructing standardized time series for these species ar[illegible] to night catches making them equivalent to day catches using the correction factors [illegible]en in Table 1.

3.1.38 Threespine stickleback (*Gasterosteus aculeatus aculeatus*) - code 361

Threespine stickleback are equally catchable in day and night (Benoît and Swain 2003). Few individuals were captured during the 1992 and 1985 comparative fishing experiments (Fig. 18; Table 2).

3.1.39 Marlin-spike grenadier (*Nezumia bairdii*) - code 410

Marlin-spike grenadier appeared to be equally catchable in day and night, although small sample sizes may limit the power to test this hypothesis (Benoît and Swain 2003).

The vessels appeared to be equally efficient at capturing this species, although there were few paired sets in both 1985 and 1992 with which to test this hypothesis (Fig. 30; Tables 2 & 3).

3.1.40 Unseparated seasnails (*Liparis* sp.) - code 500

Species identification at sea is problematic for seasnails (*Liparis* sp.). While attempts are made to identify the individuals of this genus to the species level, it is felt that this has been done inconsistently over the years and the reliability of the identification is questionable. The individuals grouped under this code would mainly be *L. gibbus* (dusky seasnail), but may also include instances of *L. atlanticus* (Atlantic seasnail), *L. fabricii* (gelatinous seasnail) and *L. liparis* (striped seasnail).

Seasnails were more catchable by the *Alfred Needler* at night (Table 1), but were equally catchable in day and night by the *Lady Hammond* (Benoît and Swain 2003).

The *Lady Hammond* was more efficient at capturing seasnails than the *Alfred Needler* (Fig. 31; Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Seasnail catches by the *Lady Hammond* must be divided by 2.915 to be comparable to the *Alfred Needler*.

The *Lady Hammond* also tended to catch more seasnails than the *E.E. Prince*. This difference approached significance despite very small sample size (Table 2). However, this apparent difference in fishing efficiency was eliminated when catches by the *Lady Hammond* were adjusted to *Alfred Needler* equivalents (Fig. 31).

In constructing standardized time series for this species, night catches by the *Alfred Needler* must be converted to daytime equivalents using the correction factor given in Table 1, and catches by the *Lady Hammond* must be adjusted to be equivalent to those by the *Alfred Needler*.

3.1.41 Lumpfish (*Cyclopterus lumpus*) - code 501

Lumpfish were significantly more catchable during the day by the *Alfred Needler* (Table 1), though not by the *Lady Hammond* (Benoît and Swain 2003). Too few individuals were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, night catches by the *Alfred Needler* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for lumpfish.

3.1.42 Spiny lumpsucker (*Eumicrotremus spinosus*) - code 502

Spiny lumpsuckers were more catchable at night by both the *Alfred Needler* and the *Lady Hammond* (Table 1). Too few individuals were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. However, Benoît et al. (2003a) noted a clear break in the abundance index time series for this species around 1985, as they were captured only once prior to that year (in 1974), but annually since then. This apparent break cannot be explained solely by a low probability of capture during the pre-1985 surveys (daytime fishing only) because it remains even if the post-1985 time series is restricted to daytime sets only (H. Benoît, *unpublished analysis*). Although a diel difference in the probability of capture likely contributed to the break, it is also likely that a real increase in abundance around 1985 and an increase in catchability when switching to the *Lady Hammond* and Western IIA trawl were also involved. Because it is impossible to distinguish between these possibilities, we strongly urge caution in interpreting any trend in abundance for this species based on years prior to 1985.

3.1.43 Fish doctor (*Gymnelus viridus*) - code 616

Fish doctors were more catchable by the *Alfred Needler* at night (Table 1). They were very rare in the survey catches prior to 1992 and too few individuals were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels.

3.1.44 Snakeblenny (*Lumpenus lumpretaeformis*) - code 622

Snakeblenny were more catchable by the *Alfred Needler* at night (Table 1), but equally catchable day or night by the *Lady Hammond* (β_d =0.352±0.374 (SE), P=0.310). The vessels did not appear to differ in efficiency at catching this species (Fig. 23; Tables 2 & 3). Thus, night catches by the *Alfred Needler* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for snakeblenny.

3.1.45 Fourline snakeblenny (*Eumesogrammus praecisus*) - code 626

Benoît and Swain (2003) found that fourline snakeblenny were much more catchable at night by both the *Alfred Needler* and the *Lady Hammond* and that the strength of that effect varied with both body length and fishing depth. The relatively small number of catches of this species precluded estimating simultaneous length and depth-dependent corrections for diel variation in catchability. We chose to estimate correction factors as a function of depth by combining the catches from the two series to estimate an overall depth-dependent diel effect. Using a Poisson regression, as was done in Benoît and Swain

(2003), we estimated the diel effect in individual 50 m depth bins and fit a linear regression to these point estimates in order to obtain a continuous relationship with depth (Fig. 32; Table 1).

The *Alfred Needler* and the *Lady Hammond* appeared to be equally efficient at capturing fourline snakeblenny, though sample size in the 1992 experiment was very low (Fig. 33; Tables 2 &3). Fourline snakeblenny were captured in only three sets by the *Lady Hammond* and no sets by the *E.E. Prince* in 1985. Thus, we have adjusted night catches to be equivalent to day catches using the depth-dependent factor given in Table 1, but have applied no other adjustments to construct a standardized time series for fourline snakeblenny.

A clear break occurs in 1985 in the time series for this species. The *E.E. Prince* captured on average fewer than 0.03 individuals per tow whereas the *Alfred Needler* and the *Lady Hammond* have consistently captured ten times that amount (Fig. 33, lower panel). This difference likely stems from the fact that the *E.E. Prince* fished only during the day and fourline snakeblenny are three times less likely to be captured during daylight. As a result, we recommend using only daytime catches for analyses of this species that begin in 1971, or limiting analyses to 1985 onward.

3.1.46 Ocean pout (*Zoarces americanus*) - code 640

Ocean pout are more catchable at night, although analyses subsequent to the publication of Benoît and Swain (2003) suggest that the strength of this effect decreases with increasing length (Table 1). This effect was consistent for both the *Lady Hammond* and the *Alfred Needler* so the catches from both vessel series were pooled to increase sample size and estimate a single relationship (Fig. 34).

The *Alfred Needler* was more efficient than the *Lady Hammond* at capturing ocean pout (Fig. 35; Table 2). This difference in catchability was unaffected by depth (Table 3) and did not appear to vary with fish length. Ocean pout catches by the *Lady Hammond* must be multiplied by 1.818 to be comparable to the *Alfred Needler*.

No significant difference in fishing efficiency for ocean pout was evident between the *E.E. Prince* and the *Lady Hammond*, regardless of whether catches of the latter were corrected to be like those of the *Alfred Needler* (Fig. 35; Tables 2 & 3). However, few paired sets were available to test this hypothesis. Thus, we have adjusted night catches to be equivalent to day catches using the length-dependent factor given in Table 1 and have adjusted the *Lady Hammond* catches to be like those of the *Alfred Needler* to construct a standardized time series for ocean pout.

3.1.47 Unseparated eelpouts (Lycodes sp.) - code 642

Species identification at sea is problematic for eelpouts (*Lycodes* sp.). While attempts have been made to identify the individuals of this genus to the species level, it is felt that this has been done inconsistently over many survey years and the reliability of the identification is questionable. The individuals grouped under this code are mainly *L. lavalaei* (Newfoundland eelpout) and *L. vahlii* (Vahl's eelpout), with a few possible instances of *L. reticulatus* (Arctic eelpout), *L. pallidus* (pale eelpout) and *L. esmarki* (Esmark's eelpout). Although there has been a concerted effort since 2001 to correctly identify these species based on a key prepared specifically for the southern Gulf (K.J. Sulak, U.S. Geological Survey, Gainesville, Florida, *unpublished report*), any analyses extending prior to that year should group the species to the genus level.

Eelpout are more catchable at night by both the *Lady Hammond* and the *Alfred Needler*, although the strength of this effect decreases with increasing length (Table 1).

The *Lady Hammond* was more efficient than the *Alfred Needler* at capturing eelpouts (Fig. 36; Table 2). This difference in catchability was unaffected by depth (Table 3), but appears to depend on body length (Fig. 37). The relationship between β_v, estimated for 3 cm intervals, and length was best described by a linear regression (Fig. 37):
$\beta_{v\ length} = 1.2682 - (0.0179 \times length)$.

This relationship applies to lengths between 24-57 cm; the correction for 24 cm eelpouts should be applied to all individuals smaller than 24 cm, with a similar logic applying to all individuals larger than 57 cm. Eelpout catches of a given body length by the *Lady Hammond* must be divided by $exp(\beta_{v,\ length})$ to be comparable to those by the *Alfred Needler*.

Once corrected to be like the *Alfred Needler*, the *Lady Hammond* captured eelpouts with an efficiency similar to that of the *E.E. Prince* (Fig. 36; Tables 2 & 3). For uncorrected catches, the *Lady Hammond* was also more efficient than the *E.E. Prince* at capturing eelpouts.

Thus, we have used length-dependent factors to adjust night catches to be equivalent to day catches (Table 1) and to adjust the *Lady Hammond* catches to be like those of the *Alfred Needler* (Table 2) to construct a standardized time series for the eelpouts.

3.1.48 Barracudina (Paralepididae) - code 713

Although the vast majority of instances in the survey records are of white barracudina (*Arctozenus risso*), barracudinas have been grouped to the family level (Paralepididae) because there are a few unconfirmed records of *Paralepis coregonoides*.

Barracudinas were more catchable by the *Alfred Needler* during the day (Table 1), but were too rare in catches by the *Lady Hammond* to test for diel differences in catchability

to this vessel (H. Benoît, *unpublished results*). However, given that the diel effect is typically very similar among vessels for many species (see Fig. 3c in Benoît and Swain 2003) we recommend applying the correction factor derived from the *Alfred Needler* series to the *Lady Hammond* catches.

Too few individuals were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, night catches by the *Alfred Needler* and the *Lady Hammond* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for barracudina.

3.1.49 Overall body-size composition

Total length frequencies from the comparative fishing experiments for all fish species combined were examined to ensure that any existing length-dependent differences in fishing efficiency between vessels could be corrected by applying the adjustment factors listed in Table 2. The overall length frequencies in 1992 were largely influenced by the aforementioned large catches of herring (section 3.1.13; Fig. 38a). When herring are excluded from the length-frequency it is apparent that the *Lady Hammond* and *Alfred Needler* generally fished with similar efficiency across all lengths (Fig. 38b). Applying the correction factors listed in Table 2 further improved the similarity between the vessels when capturing fish less than 18 cm.

The *E.E. Prince* fishing with the Yankee 36 trawl generally captured fewer fish than the *Lady Hammond* with the Western IIA trawl (Fig. 38c). This difference was greatest for small bodied fish (<20 cm). Applying the correction factors listed in Table 2 greatly increases the similarity between the two vessels when catching fishes of most lengths, although the corrections are not quite strong enough to account for differences in efficiency when capturing 30-42 cm individuals. Nonetheless the differences that remain for fish of these lengths after correction represent on average less than a 15% difference in efficiency. This is well within the margin of error expected in such a comparative fishing experiment.

3.2 Epi-benthic and pelagic macroinvertebrates (General)

The only non-fish taxa that have been consistently sorted and enumerated in the September survey since 1971 are squid (mainly short-fin squid, *Illex illecebrosus*) and American lobster (*Homarus americanus*). Although there are catch records for crabs (*Cancer* sp., *Chionoectes opilio*, *Hyas* sp., and *Lithodes maja*), shrimp (Pandalidae and Crangonidae) and scallops (Pectinidae) dating back to 1971, these species were not consistently enumerated until 1980. The sorting, identification and recording of catches of all other macroinvertebrates did not become part of the standard survey protocol until 1985. Furthermore, while efforts have been made to identify them to the lowest practical taxonomic level, a refining in the taxonomic identification of several of these taxa is evident in the data from 1985 to the mid-1990s. As such, we recommend grouping these

taxa to the Class or Order level for any analyses spanning that period. This is what we have done for the purpose of this report.

The only non-fish taxon for which representative length frequencies were consistently obtained since 1971 is short-fin squid (mantle length). Consistent measurements of lobster carapace length began in September 1992, consequently no lengths were recorded as part of the August 1992 comparative fishing experiment. Consistent recording of snow crab carapace width began in 2001, and the standard survey protocol for individual size measurements was extended to all crabs (carapace width), all scallops (shell height) and octopus (total relaxed length) in 2002.

3.2.1 Pandalus shrimp (Pandalidae F.) - code 2200

During the 2002 and 2003 surveys, collections of shrimp were made at most fishing sets where they were captured. Species identifications subsequently made in the laboratory have allowed for the partitioning of these catches to over 15 separate decapod shrimp species (previously shrimp were typically, and incorrectly, split into two coarse groups: Pandalid and Crangonid shrimp). It is hoped that such a protocol will be possible for future surveys.

Pandalus shrimp did not show any diel variation in catchability to the *Alfred Needler* (Benoît and Swain 2003). There were too few catches of shrimp from 1985-1991 to test a similar hypothesis for the *Lady Hammond*.

The *Alfred Needler* was more efficient than the *Lady Hammond* at capturing Pandalus shrimp (Fig. 39; Table 2). This difference in catchability was unaffected by fishing depth (Table 3). Catches by the *Lady Hammond* must be multiplied by 2.645 to be comparable to the *Alfred Needler*. This is the only adjustment required to obtain a standardized series for pandalus shrimp as they occurred in too few paired sets in 1985 to assess the relative efficiency of the *Lady Hammond* and the *E.E. Prince*.

3.2.2 Snapping shrimp (Crangonidae Family) - code 2400

Snapping shrimp were more catchable by the *Alfred Needler* at night (Table 1) but were too rare in catches by the *Lady Hammond* to test for diel differences in catchability to this vessel. However, given that the diel effect is typically very similar among vessels for many species (see Fig. 3c in Benoît and Swain 2003) we recommend applying the correction factor derived from the *Alfred Needler* series to the *Lady Hammond* catches.

Too few individuals were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, night catches by the *Alfred Needler* and the *Lady Hammond* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for snapping shrimp.

3.2.3 Rock crab (*Cancer irroratus*) - code 2513

Rock crab did not show any diel variation in catchability to either the *Alfred Needler* or the *Lady Hammond* (Benoît and Swain 2003). The research vessels did not differ in their efficiency at capturing rock crab, although there were few set pairs in 1985 with which to test for a difference (Fig. 39; Table 2). Thus, no adjustments are required to obtain a standardized series for this species.

3.2.3 Toad crabs (*Hyas* sp.) - code 2520

The 2002 survey was the first year that there was a concerted effort to distinguish the two species of this genus which occur in the southern Gulf of St. Lawrence: *Hyas coarctatus* and *Hyas araneus*. Although this will be the standard protocol for all future surveys, historical catch information should be analyzed at the genus level only.

Toad crabs were more catchable at night by both the *Lady Hammond* and the *Alfred Needler* (Table 1). The vessels did not differ significantly in relative fishing efficiency (Fig. 39; Tables 2 & 3). Thus, night catches by the *Alfred Needler* and the *Lady Hammond* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for toad crabs.

3.2.4 Northern stone crab (*Lithodes maja*) - code 2523

Northern stone crabs did not show any diel variation in catchability to either the *Alfred Needler* or the *Lady Hammond* (Benoît and Swain 2003). The research vessels did not differ in their efficiency at capturing northern stone crab, although there were very few set pairs in 1992 and in 1985 with which to test for a difference (Fig. 39; Table 2). Thus, no adjustments are required to obtain a standardized series for this species.

3.2.5 Snow crab (*Chionoectes opilio*) - code 2526

Snow crabs were more catchable at night by both the *Lady Hammond* and the *Alfred Needler* when considering body-size aggregated catches (Table 1). However, information on the carapace-width distribution in survey catches collected since 2001 suggests that this effect may be size-dependent, with small crabs (<100mm) being more catchable during the day and large crabs (>100mm) being more catchable at night. Consequently a size-aggregated correction should be applied to catches from 1985-2000 and a size-dependent correction applied for those years where size-frequencies were recorded (i.e. 2001 onwards).

The *Alfred Needler* and the *Lady Hammond* were equally efficient at capturing snow crab (Fig. 40; Tables 2 &3). The *Lady Hammond* was however more efficient than the *E.E.*

Prince, although this did not depend on fishing depth. Catches by the E.E. Prince should be multiplied by 2.107 in order to be comparable to the *Alfred Needle*r and the *Lady Hammond*.

3.2.6 American lobster (*Homarus americanus*) - code 2550

Lobster were equally catchable in day and night by both the *Lady Hammond* and the *Alfred Needler* when considering body-size-aggregated catches (Table 1). However, information on length-disaggregated catches by the *Alfred Needler* collected since 1992 suggest that this null result reflects a higher nighttime catchability of small lobster (<80 mm carapace length) and a higher daytime catchability of large lobster (>80 mm). Consequently, a size-dependent correction should be applied for those years where size-frequencies were recorded (i.e. September 1992 onwards). This is the only correction that is required to obtain a standardized series, as the fishing vessels did not differ significantly in relative fishing efficiency when catching lobster (Fig. 40; Tables 2 & 3).

3.2.7 Sea mouse (*Aphrodita* sp.) - code 3212

Sea mice were more catchable by the *Alfred Needler* at night (Table 1), but sample size limited our ability to test for a similar effect for the *Lady Hammond*. However, given that the diel effect is typically very similar among vessels for many species (see Fig. 3c in Benoît and Swain 2003) we recommend applying the correction factor derived from the *Alfred Needler* series to the *Lady Hammond* catches.

Too few individuals were captured during the comparative fishing experiments to test for differences in fishing efficiency between vessels. Thus, night catches by the *Alfred Needler* and the *Lady Hammond* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for sea mice.

3.2.8 Whelks (*Buccinum* sp.) - code 4210

Whelks did not display any diel variation in catchability (H. Benoît, *unpublished results*). The *Lady Hammond* and the *Alfred Needler* did not differ significantly in relative fishing efficiency when catching whelks, although in 11 of 12 relevant set pairs only one of the two vessels captured this species (Fig. 40; Tables 2 & 3). Thus, no adjustments are required to obtain a standardized series for whelks.

3.2.9 Scallop (Pectinidae Family) - code 4322

Scallops do not display any diel variation in catchability (H. Benoît, *unpublished results*).

The *Alfred Needler* was more efficient than the *Lady Hammond* at capturing scallops (Fig. 40; Tables 2 & 3). However, in 12 of 16 relevant set pairs where the *Alfred Needler* captured scallops, the *Lady Hammond* did not. Furthermore, applying the resulting correction factor appears to introduce a very large break in the time series for this species (Fig. 40) suggesting that the correction factor may not be appropriate. This likely stems from 16 sets in the *Lady Hammond* comparative fishing catch record containing "unidentified molluscs", whereas all mollusc records for the *Alfred Needler* were identified to finer taxonomic resolution. These unidentified molluscs would certainly not be either squid or octopus, and would most likely be bivalves or gastropods. Grouping all unidentified molluscs, bivalves and gastropods for both vessels, we find that this group was equally catchable to both vessels (β_v =0.9376, SE=0.4812, P=0.064). In the absence of better information at the appropriate level of taxonomic resolution we do not recommend applying any correction for differences in fishing efficiency between vessels for scallops or any other bivalve or gastropod molluscs.

3.2.10 Short-fin squid (*Illex illecebrosus*) - code 4511

Short-fin squid were more catchable during the day by both the *Lady Hammond* and the *Alfred Needler* (Table 1). The fishing vessels did not differ significantly in relative fishing efficiency when catching this species (Fig. 41; Tables 2 & 3). Thus, night catches by the *Alfred Needler* and the *Lady Hammond* are adjusted to be equivalent to day catches, but no other adjustments are applied to construct standard time series for short-fin squid.

3.2.11 Octopus (Octopoda Order) - code 4521

Octopus did not display any diel variation in catchability to the *Lady Hammond* (Benoît and Swain 2003). Catchability of octopus to the *Alfred Needler* appeared to be greater during the day at a marginal level of significance (Benoît and Swain 2003). However, applying this correction produces a significant break in the time series for this taxon in 1992 (H. Benoît, *unpublished results*), and we have thus not applied this adjustment to produce a standardized time series for octopus.

The *Lady Hammond* and *Alfred Needler* did not differ significantly in relative fishing efficiency when catching this taxon, although sample size was very small (Fig. 41; Tables 2 & 3). Thus, no adjustments are required to obtain a standardized series for octopus.

3.2.12 Chitons (Polyplacophora Class) - code 4700

Chitons do not display any diel variation in catchability to either research vessel (H. Benoît, *unpublished results*). The *Lady Hammond* and *Alfred Needler* did not differ significantly in relative fishing efficiency for this taxon, although sample size was very

small (Fig. 41; Table 2). Thus, no adjustments are required to obtain a standardized series for chitons.

3.2.13 Starfish (Asteroidea sub-Class) - code 6100
3.2.14 Mud stars (*Ctenodiscus crispatus*) - code 6115
3.2.15 Sunstars (*Solaster* sp.) - code 6120

There were inconsistencies in the identification of starfish on the *Lady Hammond* and the *Alfred Needler* during the 1992 comparative fishing. Although analyses were performed for two of these taxa, mud stars and sunstars (Fig. 42; Table 2), these results likely do not include individuals that were identified to the sub-class level only. Consequently, we suggest grouping species codes 6100-6135 as starfish, and making corrections for catchability at that level of taxonomic resolution. Therefore we focus our discussion for the purpose of this report on starfish as a whole.

The starfish do not display any diel variation in catchability (H. Benoît, *unpublished results*).

The *Lady Hammond* was more efficient than the *Alfred Needler* at capturing starfish (Fig. 41; Tables 2). This difference was unaffected by fishing depth (Table 3). Catches by the *Lady Hammond* must be divided by 2.129 to be comparable to those by the *Alfred Needler*.

The *E.E. Prince* was more efficient at capturing starfish than was the *Lady Hammond*, a difference that is exacerbated by the correction recommended above (Fig. 41; Table 2). This difference varied significantly with fishing depth (Table 3), although this was largely the result of two tows in deep waters where the *E.E. Prince* captured more starfish. Nonetheless, estimating a correction for the efficiency of the *E.E. Prince* at capturing starfish is moot as the time series for that taxon cannot be extended prior to 1985 (see section 3.2). Thus, adjusting the *Lady Hammond* catches to be like those of the *Alfred Needler* is the only correction used to construct a standardized time series for starfish.

3.2.16 Brittle stars (Ophiuroidea sub-Class) - code 6200
3.2.17 Basket stars (Gorgonocephalidae) - code 6300
3.2.18 Sea urchins (*Strongylocentrotus* sp.) - code 6400
3.2.19 Sea cucumbers (Holothuroidea) - code 6600

None of these four taxa display any diel variation in catchability (H. Benoît, *unpublished results*). No significant differences in fishing efficiency between vessels were evident for these taxa, though a tendency for the *Lady Hammond* to catch more basket stars than the *Alfred Needler* approached significance (Figs 42 & 43; Tables 2 & 3).

3.2.20 Sea anemones (Anthozoa Class) - code 8300

Sea anemones do not display any diel variation in catchability (H. Benoît, *unpublished results*).

The *Lady Hammond* was more efficient at capturing sea anemones than was the *Alfred Needler*, a difference that was unaffected by fishing depth (Fig. 43; Tables 2 & 3). Catches by the *Lady Hammond* must be divided by 2.437 to be comparable to the *Alfred Needler*.

The *E.E. Prince* and the *Lady Hammond* were equally efficient at capturing sea anemones (Fig. 43; Table 2), although again this point is moot as the time series for that taxon cannot be extended prior to 1985 (see section 3.2). Thus, adjusting the *Lady Hammond* catches to be like those of the *Alfred Needler* is the only correction used to construct a standardized time series for sea anemones.

3.2.21 Jellyfish medusas (Scyphozoa Class) - code 8500

Jellyfish are more catchable by the *Alfred Needler* during the day (Table 1). They did not display any diel variation in catchability to the *Lady Hammond*, although this is likely due to low power to test the hypothesis as a result of small sample size (Benoît and Swain 2003).

The fishing vessels did not differ in their efficiency when catching jellyfish (Fig. 43; Tables 2 & 3). Adjusting night catches by the *Alfred Needler* to be equivalent to daytime catches is the only adjustment that is required to obtain a standardized series for jellyfish medusas.

3.2.22 Sponges (Porifera Phylum) - code 8600

Sponges did not display any diel variation in catchability (H. Benoît, *unpublished results*), nor did the vessels differ in their efficiency when catching them (Fig. 44; Tables 2 & 3). Thus, no adjustments are required to obtain a standardized series for sponges.

4. Other Information Relevant to the Analysis of the September Survey Data

Aside from correcting for diel and vessel differences in catchability, there are a number of other corrections or considerations that should be taken into account when analysing the southern Gulf of St. Lawrence survey data. These are briefly discussed in this section:

Experiment types: Experiment types denote the type of fishing set that was conducted (1 – stratified random survey set, 2 – fixed station survey set, 3 - unrepresentative catch / null set, 4 – part of catch left unsampled, 5 – comparative fishing experiment, 6 – tagging study, 7- mesh selectivity study, 8 – exploratory fishing, 9 - hydrography). With only two exceptions, all experiment types other than three (3) are included in analyses. These exceptions are experiment types eight (8) and nine (9) in survey P278 (1982) and type eight in survey N192 (1993).

Repeat sets: In certain years, stations were sampled repeatedly during the regular survey to look at fishing depletion effects (G. Poirier, *unpublished analyses*), to look for diel differences in catchability (Benoît and Swain 2003) or for comparisons of vessel fishing efficiency (1985 comparative fishing experiment, this report). These repeat sets are listed in Table 4.

For the majority of species captured in the annual survey, catches in these repeat sets should be averaged prior to calculating stratified means and variances. The only exceptions are white hake and winter flounder which show attraction and depletion effects respectively (G. Poirier, *unpublished analyses*). Only the first of the repeat sets should be used when calculating stratified means and variances for these two species.

Strata sampled (Fig. 1): With a few minor exceptions noted in the next paragraph, strata 415-439 have been sampled annually since 1971. In addition to these, coastal strata 401-403 have been sampled annually since 1984. When calculating abundance index time series it is important to ensure that a consistent suite of strata are included for the entire series.

Despite the preceding, some strata were not sampled in certain years: strata 424 and 428 (in 1978) and stratum 421 (1983 and 1988). The traditional approach has been to ignore these omissions (i.e., implicitly assume that the average catch in the missed strata was equal to the average over the remainder of the survey area). This approach has only a small to moderate effect on the stratified means and variance given the small number of cases and the generally small area of these strata. A second option is to omit these strata entirely from time series that span the years in question, although this results in potentially significant information loss for the other years. A third approach is to fill in the missing strata using a multiplicative analysis with year and stratum as model terms (e.g., Swain et al. 1998). This approach assumes that there is no year x stratum interaction (i.e., no change in distribution between years). A fourth and final alternative, which is

simple to apply in a multi-species context and which we presently favour, is to assign an average catch rate to these strata based on the average in neighbouring or similar strata (i.e., the weights for missed strata are apportioned to nearby strata in the same depth zone). This is likely a more realistic assumption than assuming that catches in the missed strata equal the average over the entire survey area as given in the first option listed above.

5. RECOMMENDATIONS

Differences in catchability between vessels, gears and diel periods may vary with physical factors such as depth, substrate and possibly weather and biotic factors such as body size. Studies aimed at quantifying these differences need to be designed to identify the effects of these factors so that they may be incorporated in corrections. Controlling for spatial variation in resource abundance is a major difficulty in estimating diel effects on catchability and relative fishing efficiency between vessels and gears. Statistical control of spatial variability is often used to estimate diel effects on catchability (Casey and Myers 1998; Swain and Poirier 1998; Hjellvik et al. 2002; Benoît and Swain 2003). This requires very large sample sizes and is generally not an option for estimating relative fishing efficiency between vessels or gears. In this case, paired fishing experiments are usually used to control for spatial variation in catch rates. However, in most cases the statistical power of these experiments is likely very low (reviewed briefly in Pelletier 1998; many examples in this study). This is particularly true for taxa that occur at low abundance, have low catchability (often smaller-bodied organisms), or which are locally abundant in only a small portion of the survey area. Thus, a tenet of ongoing survey programs should be to avoid having to correct for systematic changes in catchability by making long-term (decadal) commitments to maintain the same survey vessel and gear. Seasonal changes in catchability also occur, and cannot be corrected for, so it is also essential to maintain the same survey timing. Finally, efforts should be made to avoid any systematic diel bias by ensuring that fishing sets are reasonably randomized with respect to time of day.

Changes in survey vessels are unavoidable in the long-term though, and comparative fishing is the only reliable manner of estimating relative fishing efficiency of vessels (H. Benoît, *unpublished analyses*). Based on our experience and that of others (reviewed by Pelletier 1998), we recommend the following when intercalibration experiments are necessary:

- Designs based on paired or parallel hauls considerably reduce estimation error by controlling for spatio-temporal variability in organism abundance.
- A very large number of paired sets are needed to yield sufficient power to identify differences in fishing efficiency, especially for rare or narrowly distributed species. The low number of paired sets in the 1985 and 1992 experiments in the southern Gulf resulted in very low power in tests for most species.
- Paired hauls should be conducted throughout the survey area, in a variety of habitats. Although some comparative fishing designs target areas of high

abundance of commercially important species in the hopes of obtaining better estimates for those species, such designs raise the question of applicability of the estimates to the rest of the survey area (e.g., different depth zones of habitat types). These designs also would fail to provide estimates of relative fishing efficiency for species that are distributed differently from the target commercial species, and so are inappropriate if the aim is to estimate adjustment factors for the whole suite of species captured in a multi-species survey.

- Intercalibration experiments should be conducted in more than one year if possible, in order to minimize the impact of possible year effects in the catches, reflecting annual fluctuations in availability or catchability (e.g., Pennington and Godø 1995).
- All taxa captured by the gear, whether fish or invertebrate, should be identified to the lowest taxonomic level possible and every effort should be made to ensure that taxonomic identification is identical between the two vessels fishing comparatively.
- Representative length-frequencies should be obtained for all species of fish and for important invertebrates (e.g., crabs, lobster, squid) from all sets.

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Table 1. Correction factors (β_d) applied to the southern Gulf of St. Lawrence bottom-trawl survey data to account for diel variation in catchability (see Benoît and Swain 2003 for details). Separate β_d s were estimated for catches from the *Lady Hammond* (H) and the *Alfred Needler* (N), to account for possible vessel-dependencies. Only cases with significant length-aggregated, length-dependent or depth-dependent β_d are presented. Length- or depth-dependent β_ds are only applied over the range of lengths/depths for which the correction factors were estimated (e.g., 15-65 cm length range). For all lengths/depths below this range (e.g., <15 cm), the β_d at the minimum end of the range is applied (e.g., correction factor for 15 cm fish). A similar logic applied for lengths/depths above this range. Nighttime catches (19:00-6:59) are converted to daytime equivalents as follows: daytime equivalent catch = nighttime catch / exp(β_d).

Code	Species name		Vessel	Correction factor *L*: Length-dependent *D*: Depth-dependent	Length (mm, cm) or depth (m) range
12	*Urophycis tenuis*	White hake	H	$\beta_d = 5.030 - 0.234 \cdot L + 0.0024 \cdot L^2$	15-65 cm
			N	$\beta_d = 5.307 - 0.271 \cdot L + 0.0030 \cdot L^2$	15-65 cm
30	*Hippoglossus hippoglossus*	Atlantic halibut	N	$\beta_d = 0.781$	all
			H	[1]$\beta_d = 0.781$	all
41	*Glyptocephalus cynoglossus*	Witch flounder	H	$\beta_d = 0.2115 + 3.4729 \cdot \exp(-0.0162 \cdot D)$	50-400 m
			N	$\beta_d = 0.2115 + 3.4729 \cdot \exp(-0.0162 \cdot D)$	50-400 m
42	*Limanda ferruginea*	Yellowtail flounder	H	$\beta_d = -0.340 + 15.944 \cdot \exp(-0.101 \cdot L)$	12-36 cm
			N	$\beta_d = 0.047 + 15.305 \cdot \exp(-0.120 \cdot L)$	12-36 cm
50	*Anarhichas lupus*	Atlantic wolffish	N	[2]$\beta_d = 0.740$	all
			H	[2]$\beta_d = 0.740$	
60	*Clupea harengus*	Atlantic herring	H	$\beta_d = -2.350$	all
			N	$\beta_d = -1.963$	all
62	*Alosa* sp.	Gaspereau	H	$\beta_d = -2.382$	all
			N	$\beta_d = -1.714$	all
63	*Osmerus mordax mordax*	Rainbow smelt	H	$\beta_d = -1.955$	all
			N	$\beta_d = -1.129$	all
64	*Mallotus villosus*	Capelin	N	$\beta_d = -1.326$	all

Code	Species name		Vessel	Correction factor *L*: Length-dependent *D*: Depth-dependent	Length (mm, cm) or depth (m) range
70	*Scomber scombrus*	Atlantic mackerel	H	$\beta_d = -2.080$	all
			N	$\beta_d = -2.210$	all
112	*Phycis chesteri*	Longfin hake	H	$\beta_d = 3.675 - 0.121 \cdot L$	18-33 cm
			N	$\beta_d = 3.675 - 0.121 \cdot L$	18-33 cm
114	*Enchelyopus cimbrius*	Fourbeard rockling	H	$\beta_d = 1.257$, for $D \leq 100$ m $\beta_d = 0.249$, for $D > 100$ m	all
			N	$\beta_d = 2.293$, for $D \leq 100$ m $\beta_d = 0.324$, for $D > 100$ m	all
118	*Gadus ogac*	Greenland cod	N	$\beta_d = 0.786$	all
122	*Tautogolabrus adspersus*	Cunner	N	$\beta_d = -2.796$	all
143	*Scophthalmus aquosus*	Windowpane	H	$\beta_d = 1.387$	all
			N	$\beta_d = 0.690$	all
201	*Amblyraja radiata*	Thorny skate	H	$\beta_d = 1.650 - 0.021 \cdot L$	12-60 cm
			N	$\beta_d = 2.155 - 0.022 \cdot L$	12-60 cm
202	*Malacoraja senta*	Smooth skate	H	$\beta_d = 0.612$	all
			N	$\beta_d = 0.879$	all
204	*Leucoraja ocellata*	Winter skate	H	$^2\beta_d = 4.147 - 0.047 \cdot L$	30-66 cm
			N	$^2\beta_d = 4.147 - 0.047 \cdot L$	30-66 cm
220	*Squalus acanthias*	Spiny dogfish	N	$\beta_d = -1.071$	all
241	*Myxine glutinosa*	Atl. hagfish	N	$\beta_d = 0.765$	all
300	*Myoxocephalus octodecem-spinosus*	Longhorn sculpin	H	$\beta_d = -0.526 + 13.252 \cdot \exp(-0.098 \cdot L)$	18-36 cm
			N	$\beta_d = 0.610 + 10.053 \cdot \exp(-0.149 \cdot L)$	18-36 cm
301	*Myoxocephalus scorpius*	Shorthorn sculpin	N	$\beta_d = 0.789$	all

Code	Species name		Vessel	Correction factor *L*: Length-dependent *D*: Depth-dependent	Length (mm, cm) or depth (m) range
304	*Triglops murrayi*	Mailed sculpin	H	$\beta_d = 0.942 + 3.747 \cdot \exp(-0.0149 \cdot D)$	25-150 m
			N	$\beta_d = 0.942 + 3.747 \cdot \exp(-0.0149 \cdot D)$	25-150 m
880 was 306	*Artediellus atlanticus*	Atl. hookear sculpin	N	$\beta_d = 2.056$	all
311	Cottidae F.	Unidentified sculpins	N	$\beta_d = 1.401$	all
314	*Icelus spatula*	Spatulate sculpin	N	$\beta_d = 1.297$	all
316	*Myoxocephalus scorpioides*	Arctic sculpin	N	$\beta_d = 1.477$	all
320	*Hemitripterus americanus*	Sea raven	H	$\beta_d = 2.342 - 0.058 \cdot L$	21-42 cm
			N	$\beta_d = 2.416 - 0.046 \cdot L$	21-42 cm
340	*Aspidophoroides monopterygius*	Alligatorfish	H	$\beta_d = 1.322$	all
			N	$\beta_d = 1.329$	all
350	*Leptagonus decagonus*	Sea poacher	N	$\beta_d = 0.394$	all
500	*Liparis* sp.	Unident. seasnail	N	$\beta_d = 0.821$	all
501	*Cyclopterus lumpus*	Lumpfish	N	$\beta_d = -0.749$	all
502	*Eumicrotremus spinosus*	Spiny lumpsucker	H	$\beta_d = 2.182$	all
			N	$\beta_d = 2.537$	all
616	*Gymnelus viridis*	Fish doctor	N	$\beta_d = 1.559$	all
622	*Lumpenus lumpretaeformis*	Snakeblenny	N	$\beta_d = 1.472$	all
626	*Eumesogrammus praecisus*	Fourline snakeblenny	H	$\beta_d = 5.083 - 0.034 \cdot D$	30-150 m
			N	$\beta_d = 5.083 - 0.034 \cdot D$	30-150 m

Code	Species name		Vessel	Correction factor *L*: Length-dependent *D*: Depth-dependent	Length (mm, cm) or depth (m) range
640	*Zoarces americanus*	Ocean pout	H	$\beta_d = 3.746 - 0.0586 \cdot L$	24-66 cm
			N	$\beta_d = 3.746 - 0.0586 \cdot L$	24-66 cm
642[3]	*Lycodes* sp.	Unseparated eelpouts	H	$\beta_d = -0.164 + 4.534 \cdot \exp(-0.078 \cdot L)$	12-63 cm
			N	$\beta_d = 2.496 - 0.040 \cdot L$	12-63 cm
713	Paralepididae Family	Barracudina	N	$\beta_d = -0.444$	all
			H	$^1\beta_d = -0.444$	all
2400	Crangonidae Family	Snapping shrimp	N	$\beta_d = 1.222$	all
			H	$^1\beta_d = 1.222$	all
2520	*Hyas* sp.	Toad crabs	H	$\beta_d = 0.370$	all
			N	$\beta_d = 0.212$	all
2526	*Chionoectes opilio*	Snow crab	H	$\beta_d = 0.419$	all
			N	$\beta_d = 0.354$, when L not available, or $\beta_d = -1.857 + 0.017 \cdot L$	all or 45-115 mm
2550	*Homarus americanus*	American lobster	N	$\beta_d = 0.737 - 0.010 \cdot L$	45-120 mm
3212	*Aphrodita* sp.	Sea mouse	N	$\beta_d = 0.963$	all
			H	$^1\beta_d = 0.963$	all
4511	*Illex illecebrosus*	Short-fin squid	H	$\beta_d = -1.224$	all
			N	$\beta_d = -1.376$	all
8500	Scyphozoa Class	Jellyfish	N	$\beta_d = -0.363$	all

[1] We recommend applying the adjustment for diel differences in catchability estimated from the *Alfred Needler* catches to the *Lady Hammond* catches. Sample sizes limited our ability to estimate an adjustment for the latter and patterns for other species suggest that the diel effect is typically quite comparable between vessels.

[2] Catches from the *Alfred Needler* and the *Lady Hammond* were pooled to estimate a single correction relationship for diel differences in catchability for both vessels.

[3] Code 642 includes the following individual species codes: 598, 619, 620, 627, 641, 642, 643, 647.

Table 2. Correction factors (β_v) applied to the southern Gulf of St. Lawrence bottom-trawl survey data to account for differences in fishing efficiency among vessels. Generalized linear models were used to calculate the β_v s based on catch information from comparative fishing surveys that took place in 1992 between the *Lady Hammond* and the *Alfred Needler* (H-N) and in 1985 between the *E.E. Prince* and the *Lady Hammond* (P-H). The number of set pairs where the species was captured by at least one of the vessels is provided in the table. The statistical significance values (*P*) are from randomization/permutation tests (see text for details). Where a significant difference in fishing efficiency between the *Lady Hammond* and the *Alfred Needler* was detected, analyses of the 1985 comparative fishing were done with uncorrected *Lady Hammond* catches (P-H) as well as with *Lady Hammond* catches corrected to *Alfred Needler* equivalents (P*-H). Catches of the vessel being replaced were converted to be equivalent to catches of the replacement vessel as follows: Replacement vessel equivalent catch = former vessel catch / exp(β_v).

Code	*Species name*		*Vessels*	β_v	*SE*	*# set pairs*	*P*
10	*Gadus morhua*	Atlantic cod	**H-N**	**-0.2319** [1]	**0.0685**	**62**	**0.037**
			P-H	-0.1708	0.0653	56	0.112
			P*-H	**-0.2705**	**0.0582**	**56**	**0.007**
12	*Urophycis tenuis*	White hake	H-N	0.1242	0.0991	34	0.376
			P-H	-0.3357	0.1195	26	0.240
14	*Merluccius bilinearis*	Silver hake	P-H	-1.2546	0.6534	7	0.250
16	*Pollachius virens*	Pollock	P-H	-1.1189	0.8507	5	0.200
23	*Sebastes* sp.	Redfish	H-N	0.3103	0.1247	13	0.082
			P-H	-0.3200	0.1403	18	0.179
31	*Reinhardtius hippoglossoides*	Greenland halibut	H-N	-0.0748	0.0600	15	0.224
			P-H	-0.5888	0.2421	17	0.162
40	*Hippoglossoides platessoides*	American plaice	H-N	0.0864	0.0794	58	0.463
			P-H	**-0.3547**	**0.0626**	**55**	**0.001**
41	*Glyptocephalus cynoglossus*	Witch flounder	H-N	-0.1391	0.1436	22	0.377
			P-H	-0.2595	0.3077	19	0.428
42	*Limanda ferruginea*	Yellowtail flounder	H-N	-0.1909	0.2671	29	0.505
			P-H	-0.5089	0.1537	24	0.096

Code	*Species name*		*Vessels*	β_v	*SE*	*# set pairs*	*P*
43	*Pseudopleuro-nectes americanus*	Winter flounder	H-N	0.0792	0.7095	16	0.948
			P-H	**-0.8429**	**0.0789**	**18**	**0.001**
60	*Clupea harengus*	Atlantic herring	H-N	0.2377	0.2586	41	0.392
			P-H	-0.0877	0.1461	49	0.804
62	*Alosa* sp.	Gaspereau	H-N	0.8156	1.2521	4	0.500
			P-H	-1.3753	0.2975	14	0.055
63	Osmerus mordax	Rainbow smelt	**H-N**	**-0.7825**	**0.2203**	**10**	**0.008**
			P-H	-1.0794	0.2171	14	0.061
			P*-H	**-1.8624**	**0.2884**	**14**	**0.031**
64	*Mallotus villosus*	Capelin	**H-N**	**-0.9005**	**0.3651**	**10**	**0.041**
			P-H	**-1.9242**	**0.6637**	**9**	**0.019**
			P*-H	**-2.8256**	**0.9517**	**9**	**0.004**
70	*Scomber scombrus*	Mackerel	H-N	-1.1693	0.8604	8	0.174
			P-H	-0.9433	0.4775	10	0.059
112	*Phycis chesteri*	Longfin hake	P-H	-0.2601	0.7643	5	0.734
114	*Enchelyopus cimbrius*	Fourbeard rockling	**H-N**	**0.4962**	**0.1472**	**10**	**0.010**
			P-H	-1.1283	0.7250	9	0.310
			P*-H	-0.6323	0.6620	9	0.340
118	*Gadus ogac*	Greenland cod	H-N	0.5692	0.3234	10	0.176
143	*Scophthalmus aquosus*	Windowpane	P-H	-0.2315	0.3144	8	0.461
201	*Amblyraja radiata*	Thorny skate	**H-N**	**0.4131**	**0.1356**	**43**	**0.015**
			P-H	-0.0315	0.1864	40	0.851
			P*-H	**0.3816**	**0.1871**	**40**	**0.05**
202	*Malacoraja senta*	Smooth skate	H-N	0.2299	0.3901	8	0.556
			P-H	-0.4850	0.6911	7	0.483
204	*Leucoraja ocellata*	Winter skate	H-N	-1.749	0.9389	10	0.062
			P-H	0.0286	0.3787	14	0.960

Code	Species name		Vessels	β_v	SE	# set pairs	P
220	*Squalus acanthias*	Spiny dogfish	H-N	-0.3666	0.3857	13	0.540
			P-H	0.3380	0.4396	12	0.442
241	*Myxine glutinosa*	Atl. hagfish	P-H	1.0163	0.6168	6	0.099
300	*Myoxocephalus octodecem-spinosus*	Longhorn sculpin	H-N	-0.7891	0.2540	17	0.285
			P-H	-0.0864	0.0837	18	0.511
301	*Myoxocephalus scorpius*	Shorthorn sculpin	H-N	-1.6221	1.2051	6	0.178
304	*Triglops murrayi*	Mailed sculpin	H-N	0.1006	0.2003	24	0.773
			P-H	-0.7207	0.8454	5	0.394
320	*Hemitripterus americanus*	Sea raven	H-N	0.1889	0.3948	10	0.656
			P-H	0.4165	0.2641	12	0.115
340	*Aspidophoroides monopterygius*	Alligatorfish	H-N	0.0128	0.3494	17	0.986
			P-H	**1.5965**	**0.3987**	**12**	**0.002**
350	*Leptagonus decagonus*	Sea poacher	H-N	-0.0706	0.4300	7	0.870
340 +	350		H-N	0.1202	0.3702	21	0.773
			P-H	1.2980	1.3111	14	0.519
361	*Gasterosteus aculeatus*	Threespine stickleback	P-H	1.8859	1.1427	6	0.099
410	*Nezumia bairdii*	Malin-spike grenadier	H-N	0.2179	0.2388	7	0.362
			P-H	0.0635	0.5180	7	0.902
500	*Liparis* sp.	Seasnails	**H-N**	**1.0700**	**0.2526**	**15**	**0.016**
			P-H	-1.3154	0.4787	6	0.062
			P*-H	-0.2456	0.4678	6	0.599
622	*Lumpenus lumpretaeformis*	Snakeblenny	H-N	-1.1440	0.8260	9	0.166
			P-H	1.4754	0.5911	10	0.0703
626	*Eumesogrammus praecisus*	Fourline snakeblenny	H-N	-0.3451	0.4809	7	0.472

Code	*Species name*		*Vessels*	β_v	*SE*	*# set pairs*	*P*
640	*Zoarces americanus*	Ocean pout	**H-N**	**-0.5978**	**0.2187**	**11**	**0.012**
			P-H	0.3639	0.5561	8	0.513
			P*-H	-0.2339	0.5637	8	0.678
642[2]	*Lycodes* sp.	Unseparated eelpouts	**H-N**	**0.4828** [3]	**0.1269**	**37**	**0.003**
			P-H	**-0.7708**	**0.2043**	**26**	**0.012**
			P*-H	-0.3044	0.1997	26	0.315
2200	Pandalidae F.	Shrimp	**H-N**	**-0.9727**	**0.3130**	**23**	**0.048**
2513	*Cancer irroratus*	Rock crab	H-N	-0.7978	0.3629	12	0.082
			P-H	-0.6299	0.4975	6	0.148
2520	*Hyas* sp.	Toad crabs	H-N	0.2659	0.1252	44	0.263
			P-H	-0.3474	0.2276	26	0.321
2523	*Lithodes maja*	Northern stone crab	H-N	-0.5001	0.7214	7	0.488
			P-H	0.5287	0.8949	5	0.555
2526	*Chionoectes opilio*	Snow crab	H-N	0.0920	0.0844	50	0.338
			P-H	**-0.7451**	**0.1463**	**40**	**0.001**
2550	*Homarus americanus*	American lobster	H-N	0.7873	0.2767	14	0.086
			P-H	-0.1427	0.2087	10	0.494
4210	*Buccinum* sp.	Whelks	H-N	0.3445	0.5767	12	0.550
4320	Pectinidae F.	Scallops	**H-N**	**-1.3661**	**0.3970**	**16**	**0.001**
4511	*Illex illecebrosus*	Short-fin squid	H-N	-0.4461	0.4490	16	0.533
			P-H	0.8024	0.7388	8	0.277
4521	Octopoda Order	Octopus	H-N	-0.8915	0.8724	7	0.307
4700	Polyplacophora	Chitons	H-N	-0.1329	0.3853	6	0.730
6100[4]	Asteroidea s. C.	Starfish & sunstars	**H-N**	**0.7557**	**0.2841**	**55**	**0.002**
			P-H	**1.3994**	**0.5013**	**40**	**0.005**
			P*-H	**2.1551**	**0.5553**	**40**	**0.001**
6115	*Ctenodiscus crispatus*	Mud stars	H-N	0.5975	0.6223	11	0.337

Code	*Species name*		*Vessels*	β_v	*SE*	*# set pairs*	*P*
6120	*Solaster* sp.	Sunstars	H-N	0.3839	0.1764	40	0.090
6200	Ophiuroidea s.C.	Brittle stars	H-N	-1.0650	0.5799	9	0.120
			P-H	-0.8022	0.5427	16	0.394
6300	Gorgono-cephalidae	Basket stars	H-N	0.9187	0.3298	30	0.055
6400	*Strongylocen-trotus* sp.	Sea urchins	H-N	0.0746	0.1312	32	0.580
			P-H	-0.1155	0.2927	30	0.837
6600	Holothuroidea	Sea cucumbers	H-N	1.4815	0.6251	15	0.219
			P-H	3.2281	0.9231	8	0.242
8300	Anthozoa C.	Anemones	**H-N**	**0.8909**	**0.3695**	**10**	**0.002**
			P-H	-0.2157	0.7101	9	0.761
			P*-H	0.6751	0.7209	9	0.349
8500	Scyphozoa C.	Jellyfish	H-N	0.4937	0.7519	8	0.511
8600	Porifera P.	Sponges	H-N	0.0318	0.2496	10	0.899

[1] The relative fishing efficiency of the vessels varied in a depth-dependant manner. The catches from the *Lady Hammond* are converted to *Alfred Needler* equivalents as follows (see Nielsen 1994 for details):
Needler equiv. = *Hammond* catch*(exp(0.491908-(0.004609*depth)))*(exp(σ*55/108))
where, σ=0.01970883-(0.00038396*depth)+(0.00000278* depth^2)

[2] Code 642 includes the following individual species codes: 598, 619, 620, 627, 641, 642, 643, 647

[3] The relative fishing efficiency of the vessels varied in a length-dependent manner: $\beta_{v,\,length}$= 1.2682 – (0.0179 x length), for lengths between 24-57 cm.

[4] Due to uncertainties with the degree and consistency of taxonomic identification of starfish, analyses were conducted grouping all starfish, codes 6100-6135.

Table 3. Results of analyses of depth-dependent differences in fishing efficiency between the *Lady Hammond* and *Alfred Needler* (H-N) and between the *E.E. Prince* and the *Lady Hammond* (P-H) (see text for details). Results of analyses for the P-H comparison are based on *Lady Hammond* catches converted to *Alfred Needler* equivalents as per Table 2. Statistical significance (*P*) was assessed by randomization/permutation tests.

Code	*Species Name*	*Vessels*	*Depth parameter*	*SE*	χ^2	*# set pairs*	*P*
10	Atlantic cod	**H-N**	**0.004**	**0.002**	**5.008**	**62**	**0.012**
		P-H	-0.004	0.002	4.760	56	0.264
12	White hake	H-N	0.000	0.001	0.001	34	0.984
		P-H	-0.002	0.001	1.391	26	0.542
14	Silver hake	P-H	0.011	0.007	2.735	7	0.087
16	Pollock	P-H	0.015	0.018	0.708	5	0.406
23	Redfish	H-N	-0.004	0.002	3.043	13	0.568
		P-H	0.005	0.004	2.056	18	0.390
31	Greenland halibut	H-N	0.002	0.002	1.185	15	0.200
		P-H	-0.004	0.003	1.344	17	0.537
40	American plaice	H-N	-0.001	0.003	0.073	58	0.749
		P-H	-0.003	0.002	1.244	55	0.302
41	Witch flounder	H-N	0.001	0.002	0.200	22	0.635
		P-H	-0.008	0.003	6.713	19	0.154
42	Yellowtail flounder	H-N	-0.074	0.025	8.632	29	0.058
		P-H	0.001	0.015	0.008	24	0.866
43	Winter flounder	H-N	-0.293	0.193	2.312	16	0.201
		P-H	0.004	0.011	0.139	18	0.796
60	Atlantic herring	**H-N**	**0.029**	**0.010**	**8.617**	**41**	**0.034**
		P-H	-0.001	0.008	0.021	49	0.921
62	Gaspereau	P-H	0.028	0.030	0.876	14	0.756

Code	*Species Name*	*Vessels*	*Depth parameter*	*SE*	χ^2	*# set pairs*	*P*
63	Rainbow smelt	H-N	-0.267	0.136	3.860	10	0.232
		P-H	-0.035	0.035	1.002	14	0.464
64	Capelin	H-N	0.007	0.005	2.508	10	0.236
		P-H	-0.016	0.020	0.634	9	0.468
70	Atlantic mackerel	H-N	0.000	0.044	0.000	8	0.978
		P-H	-0.028	0.055	0.264	10	0.741
112	Longfin hake	P-H	-0.036	0.018	4.022	5	0.198
114	Fourbeard rockling	H-N	0.002	0.003	0.298	10	0.652
		P-H	-0.002	0.008	0.051	9	0.824
118	Greenland cod	H-N	-0.028	0.029	0.932	10	0.209
143	Windowpane	P-H	0.115	0.068	2.873	8	0.218
201	Thorny skate	H-N	-0.003	0.002	3.998	43	0.054
		P-H	-0.004	0.003	1.979	40	0.178
202	Smooth skate	H-N	0.002	0.008	0.101	8	0.728
		P-H	0.006	0.013	0.251	7	0.672
204	Winter skate	H-N	0.006	0.015	0.189	10	0.778
		P-H	-0.004	0.039	0.009	14	0.950
220	Spiny dogfish	H-N	0.002	0.006	0.152	13	0.644
		P-H	-0.010	0.007	2.130	12	0.144
300	Longhorn sculpin	H-N	0.025	0.048	0.278	17	0.731
		P-H	0.011	0.012	0.846	18	0.382
304	Mailed sculpin	H-N	0.008	0.004	3.388	24	0.355
320	Sea raven	H-N	-0.028	0.044	0.400	10	0.555
		P-H	0.038	0.032	1.420	12	0.234

Code	*Species Name*	*Vessels*	*Depth parameter*	*SE*	χ^2	*# set pairs*	*P*
340	Alligatorfish	H-N	0.003	0.009	0.135	17	0.843
		P-H	**0.063**	**0.031**	**4.091**	**13**	**0.037**
350	Sea poacher	H-N	0.104	0.058	3.262	7	0.111
	340 + 350	H-N	0.007	0.011	0.660	21	0.626
		P-H	-0.042	0.070	0.348	14	0.060
410	Malin-spike grenadier	H-N	-0.011	0.006	3.082	7	0.205
		P-H	-0.025	0.010	6.419	7	0.106
500	Seasnails	H-N	0.013	0.014	0.894	15	0.466
622	Snakeblenny	H-N	0.041	0.071	0.338	9	0.553
		P-H	0.015	0.022	0.486	10	0.902
626	Fourline snakeblenny	H-N	-0.089	0.052	2.912	7	0.088
640	Ocean pout	H-N	-0.052	0.089	0.346	11	0.567
		P-H	0.010	0.037	0.080	8	0.805
642	Unseparated eelpouts [1]	H-N	0.003	0.005	0.528	37	0.494
		P-H	-0.020	0.008	5.763	26	0.056
2200	Shrimp	H-N	0.003	0.005	0.280	23	0.663
2513	Rock crab	H-N	0.005	0.086	0.003	12	0.928
2520	Toad crabs	H-N	-0.015	0.009	2.835	44	0.304
		P-H	-0.012	0.014	0.716	26	0.320
2523	Northern stone crab	H-N	0.004	0.014	0.072	7	0.819
2526	Snow crab	H-N	0.000	0.002	0.004	50	0.971
		P-H	-0.005	0.004	1.196	40	0.253
2550	American lobster	H-N	0.166	0.095	3.011	14	0.209
		P-H	0.014	0.020	0.496	10	0.398

Code	*Species Name*	*Vessels*	*Depth parameter*	*SE*	χ^2	*# set pairs*	*P*
4210	Whelks	H-N	-0.112	0.054	4.368	12	0.065
4320	Scallop	H-N	0.059	0.043	1.880	16	0.419
4511	Short-fin squid	H-N	-0.003	0.013	0.062	16	0.570
		P-H	-0.004	0.014	0.088	8	0.618
4521	Octopus	H-N	0.015	0.022	0.457	7	0.706
6100	Starfish & sunstars [2]	H-N	-0.006	0.005	3.750	55	0.106
		P-H	**-0.020**	**0.005**	**19.891**	**40**	**0.001**
6200	Brittle stars	H-N	0.006	0.057	0.013	9	0.889
		P-H	0.087	0.041	4.379	16	0.019
6300	Basket stars	H-N	-0.008	0.013	0.323	30	0.644
6400	Sea urchins	H-N	0.007	0.012	0.368	32	0.472
		P-H	-0.005	0.015	0.094	30	0.738
6600	Sea cucumbers	H-N	-0.099	0.072	1.874	15	0.509
		P-H	0.234	0.234	0.994	8	0.153
8300	Anemones	H-N	-0.002	0.016	0.018	10	0.523
		P-H	-0.033	0.018	3.235	9	0.072
8500	Jellyfish	H-N	-0.036	0.042	0.703	8	0.293
8600	Sponges	H-N	0.004	0.021	0.030	10	0.692

[1] Code 642 includes the following individual species codes: 598, 619, 620, 627, 641, 642, 643, 647

[2] Due to uncertainties with the degree and consistency of taxonomic identification of starfish analyses were conducted grouping all starfish, codes 6100-6135.

Table 4. Set numbers for stations that were sampled repeatedly during certain annual surveys.

Surveys affected	*Location*	*Repeat sets (tow 1, tow 2...tow 10)*	*Location*	*Repeat sets (tow 1, tow 2...tow 10)*
P296 (1983),	3	3, 203	59	59, 259
P327 (1985),	29	29, 229	60	60, 260
H141 (1985),	33	33, 233, 333	61	61, 261
H159 (1986),	35	35, 235, 335	69	69, 269
H179 (1987)	37	37, 237	75	75, 275
	38	38, 238	81	81, 281, 381
	43	43, 243	82	82, 282, 382
	50	50, 250	85	85, 285, 385
	51	51, 251	90	90, 290
	54	54, 254, 354, 454,	91	91, 291, 391
		554, 654, 754, 854,	94	94, 294
		954, -54	111	111, 211
	55	55, 255	112	112, 212, 512, 612
	56	56, 256, 356, 456,	113	113, 513, 613
		556, 656, 756, 856,	114	114, 214
		956	120	120, 520
	57	57, 257, 357, 457,	139	139, 239
		557, 657, 757, 857	141	141, 541
	58	58, 258	142	142, 542
P312 (1984)	202	202, 302, 402	209	209, 309
	206	206, 306	210	210, 310, 410
H192 (1988)	1	1, 73	5	5, 7
	2	2, 9	8	8, 72
	3	3, 10	12	12, 16
	5	5, 7	13	13, 69
	8	8, 72	14	14, 17
	12	12, 16	18	18, 22
	13	13, 69	19	19, 23
	14	14, 17	21	21, 24
	18	18, 22	25	25, 28
	19	19, 23	26	26, 29
	21	21, 24	27	27, 30
	25	25, 28	34	34, 37
	26	26, 29	39	39, 41
	27	27, 30	40	40, 42
	34	34, 37	44	44, 47
	39	39, 41	45	45, 48

Surveys affected	*Location*	*Repeat sets (tow 1, tow 2...tow 10)*	*Location*	*Repeat sets (tow 1, tow 2...tow 10)*
H192 (1988), cont.	46	46, 53	111	111, 117
	49	49, 52	112	112, 116
	50	50, 51	113	113, 114, 115
	54	54, 57	119	119, 120
	55	55, 58	121	121, 128
	56	56, 59	122	122, 129
	60	60, 63, 64	123	123, 127
	61	61, 65	124	124, 130
	62	62, 66	125	125, 131
	74	74, 79	126	126, 132
	75	75, 78	134	134, 141
	76	76, 77	135	135, 140
	81	81, 86	136	136, 139
	82	82, 87	137	137, 138
	83	83, 88	143	143, 147
	84	84, 98	145	145, 149
	84	84, 89	146	146, 150
	85	85, 90	151	151, 154
	91	91, 92	152	152, 153
	97	97, 100	155	155, 148
	101	101, 106, 107	155	155, 160
	102	102, 108	156	156, 159
	103	103, 109	157	157, 158
	110	110, 118	161	161, 163
N846 (1998)	12	12, 16	182	182, 188
	13	13, 17	183	183, 189
	14	14, 18	196	196, 199
	19	19, 23	197	197, 200
	20	20, 25	198	198, 201
	21	21, 26	202	202, 205
	41	41, 46	203	203, 206
	42	42, 47	204	204, 207
	43	43, 48	208	208, 211
	178	178, 184	209	209, 215
	179	179, 185	210	210, 214
	180	180, 186	212	212, 216
	181	181, 187	213	213, 217
N941 (1999)	1	1, 6	3	3, 7
	2	2, 5	4	4, 9

Surveys affected	*Location*	*Repeat sets (tow 1, tow 2...tow 10)*	*Location*	*Repeat sets (tow 1, tow 2...tow 10)*
N941 (1999) cont.	20	20, 25	184	184, 188
	21	21, 26	185	185, 189
	23	23, 27	186	186, 190
	24	24, 28	193	193, 198
	35	35, 43	194	194, 201
	37	37, 42	195	195, 202
	174	174, 177	196	196, 199
	175	175, 178	197	197, 200
	176	176, 179		
N045 (2000)	2	2, 6	49	49, 50
	3	3, 7	56	56, 61
	4	4, 8	57	57, 60
	5	5, 9	58	58, 59
	10	10, 12	195	195, 196
	11	11, 14	197	197, 202
	29	29, 34	198	198, 203
	30	30, 35	199	199, 204
	31	31, 36	200	200, 205
	32	32, 37	201	201, 206
	33	33, 38		

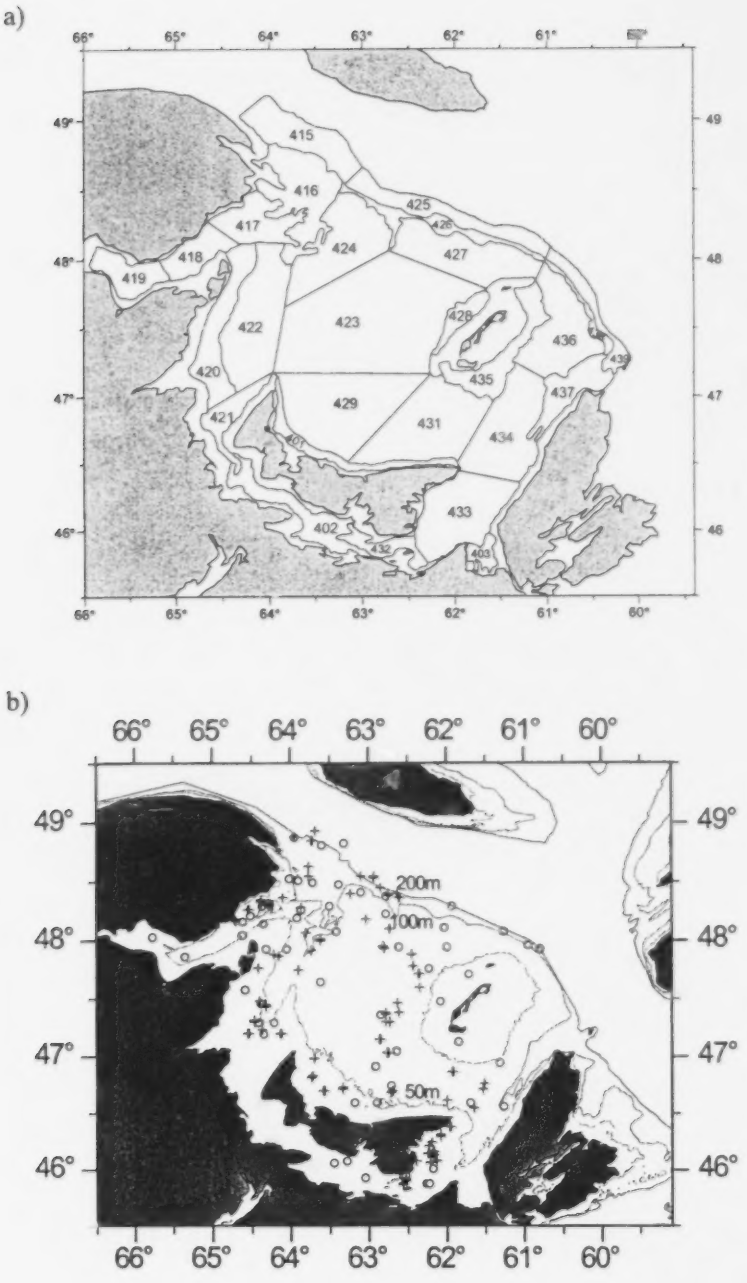

Figure 1. (a) Stratum boundaries for the southern Gulf of St. Laurence September bottom-trawl survey, and (b) location of fishing sets in the 1985 (o) and 1992 (+) comparative fishing surveys.

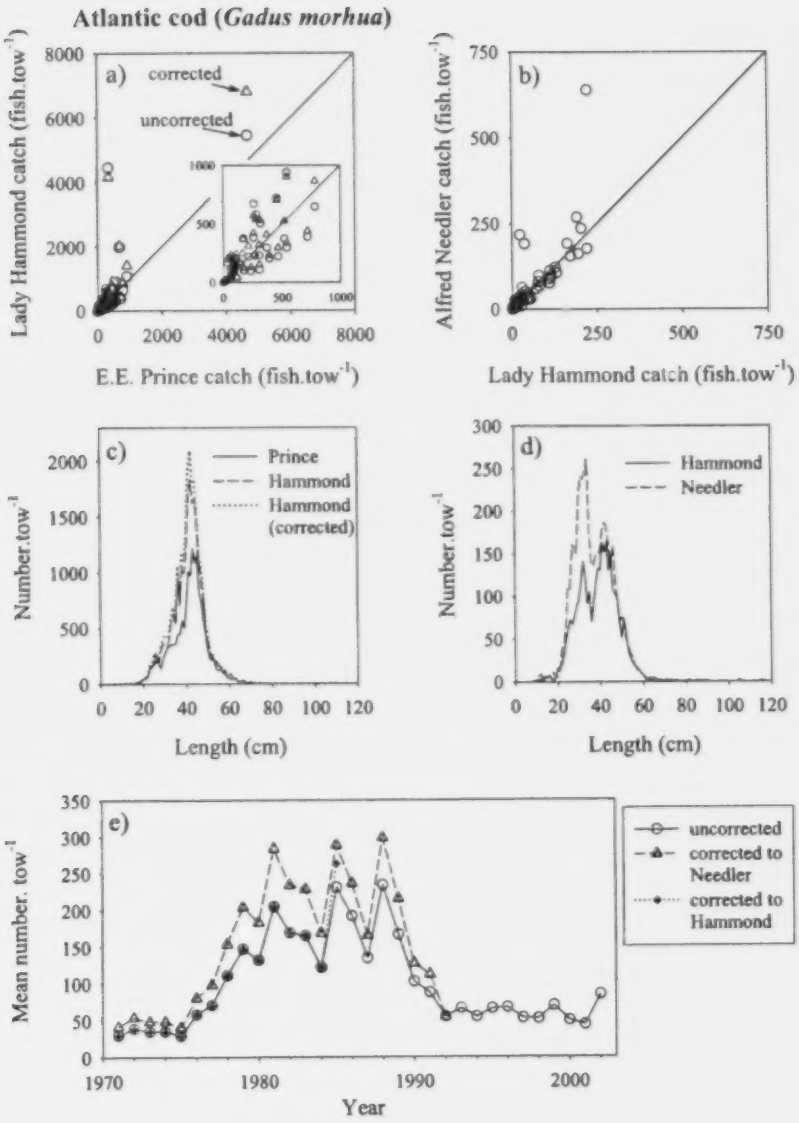

Figure 2. Cod catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

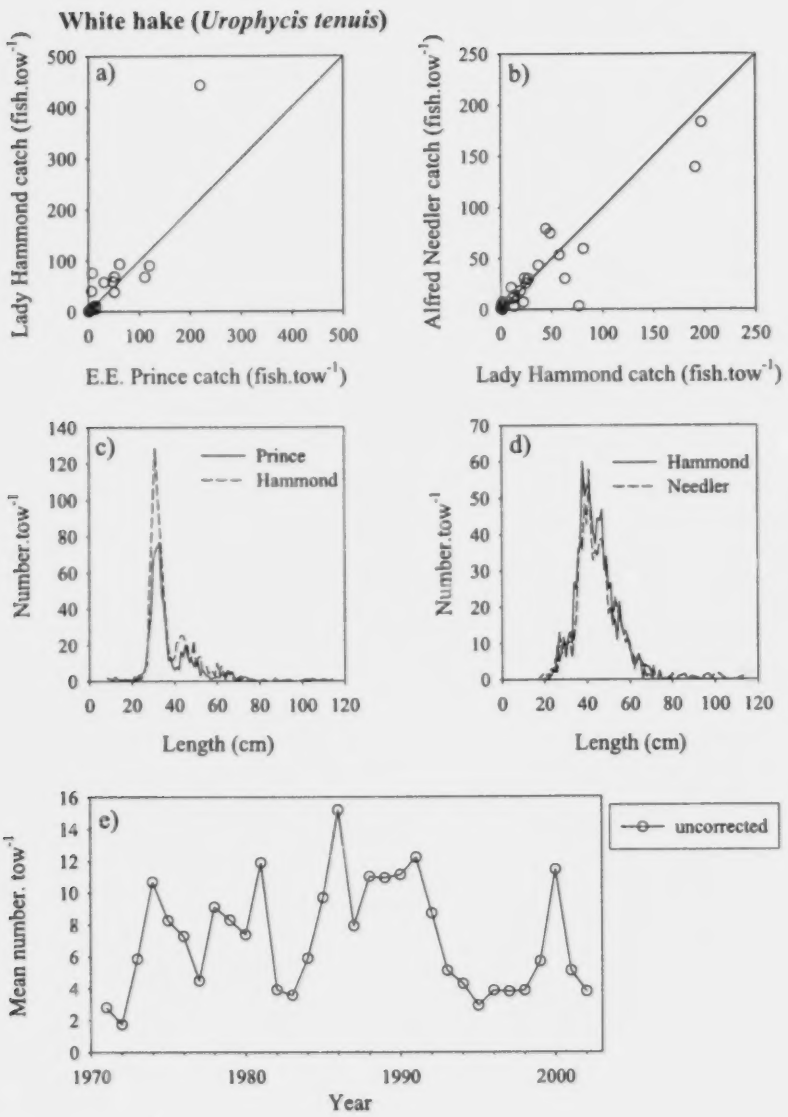

Figure 3. White hake catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for white hake is presented in panel (e).

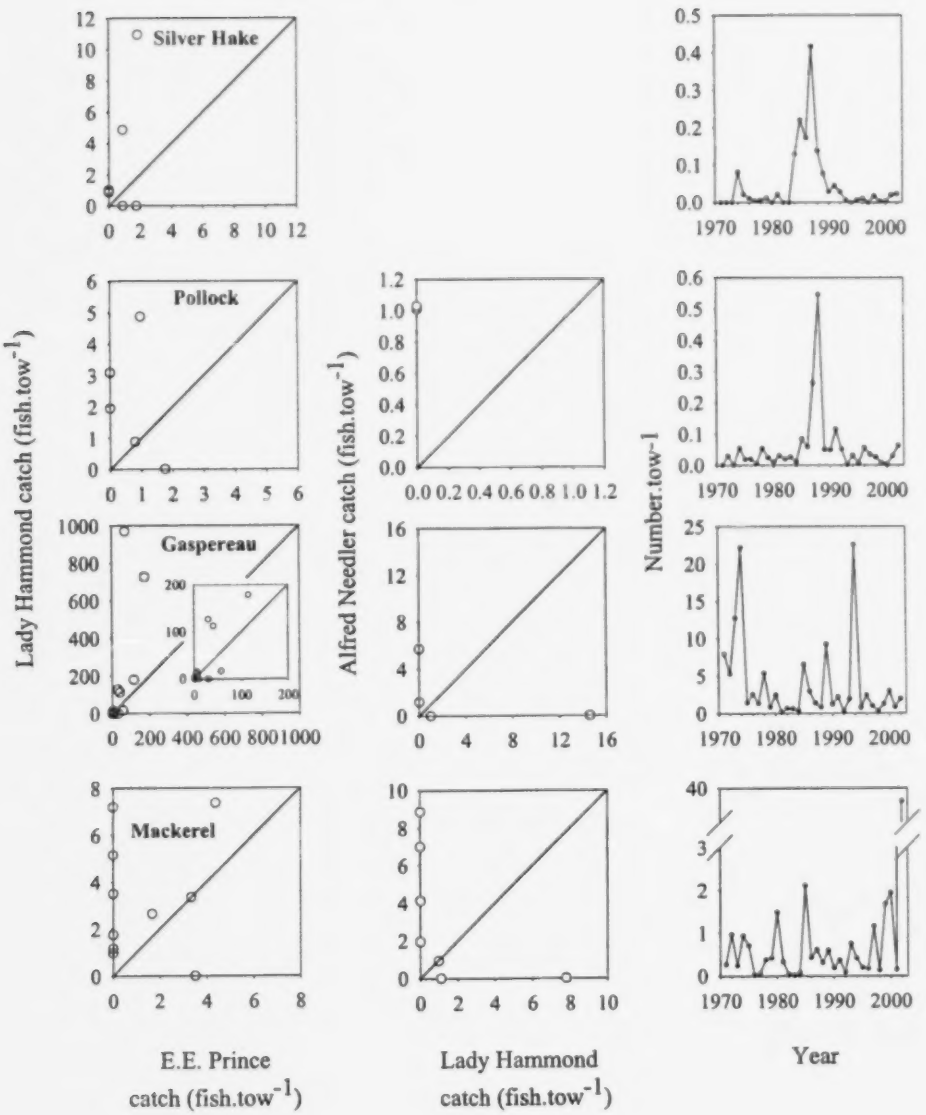

Figure 4. Catches of silver hake, pollock, gaspereau and mackerel (rows 1-4 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. The abundance index time series (mean numbers·tow^{-1}) for the respective species are presented in the rightmost column.

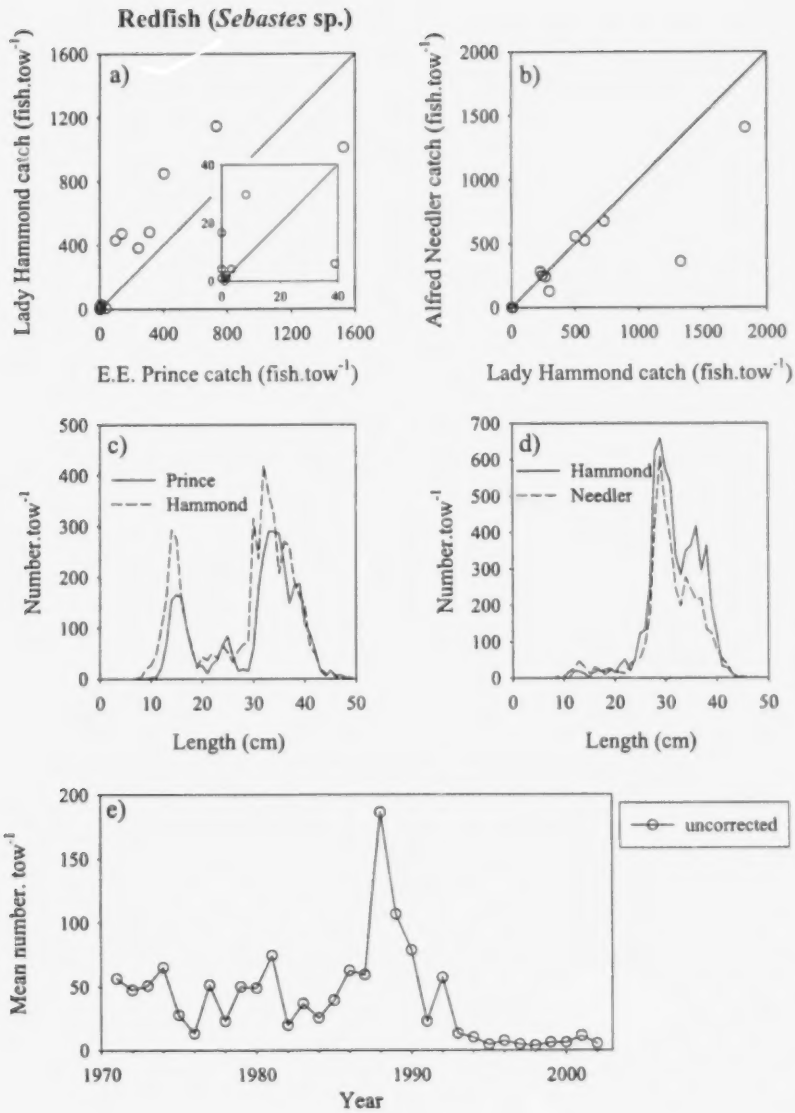

Figure 5. Redfish catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for redfish is presented in panel (e).

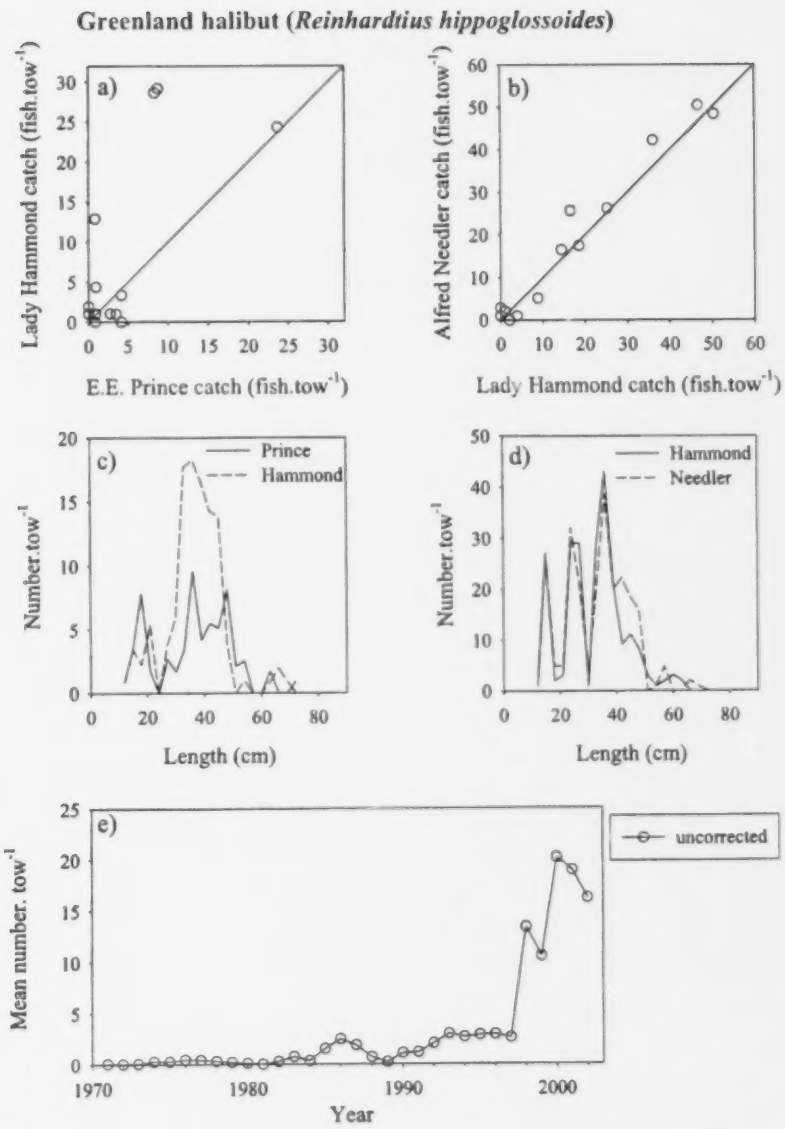

Figure 6. Greenland halibut catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for Greenland halibut is presented in panel (e).

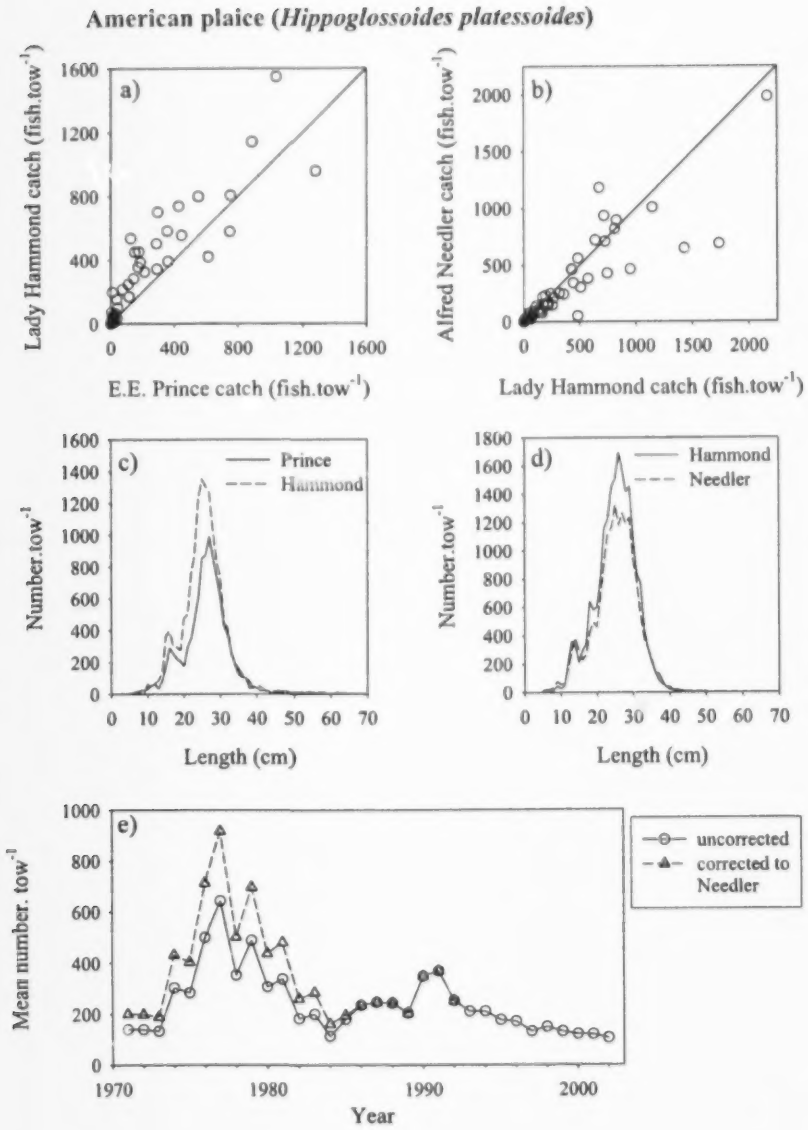

Figure 7. American plaice catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency between the *Lady Hammond* and the *E.E. Prince*.

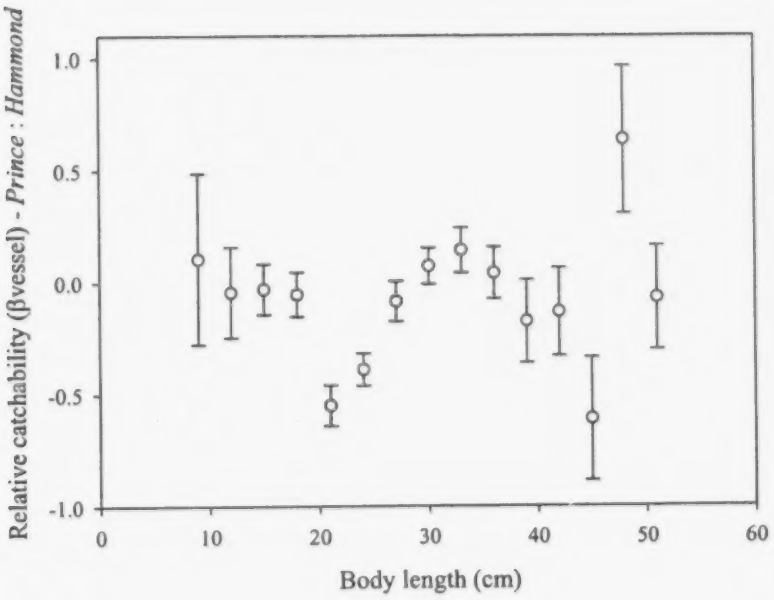

Figure 8. Relative efficiency ($\beta_v \pm$ SE) of the *E.E. Prince* and the *Lady Hammond* at capturing American plaice as a function of body length.

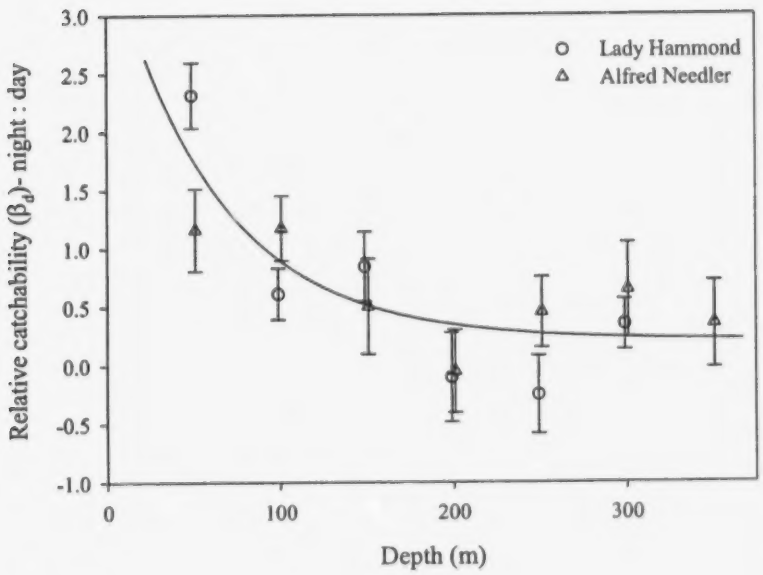

Figure 9. Diel differences in relative catchability ($\beta_d \pm$ SE) of witch flounder as a function of fishing depth, for catches by the *Lady Hammond* and the *Alfred Needler*. Depth-dependent patterns were best described by an exponential decay model (line) fit to the estimates from both vessels (see Table 1 and text for details).

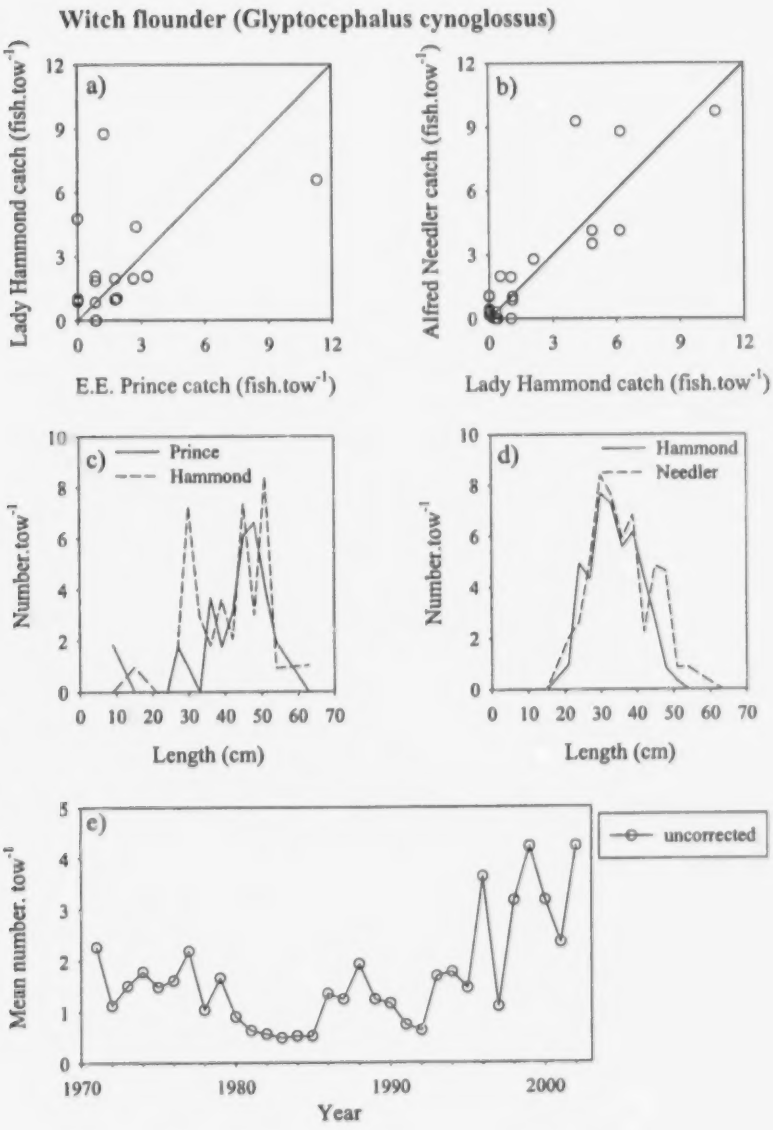

Figure 10. Witch flounder catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for witch flounder is presented in panel (e).

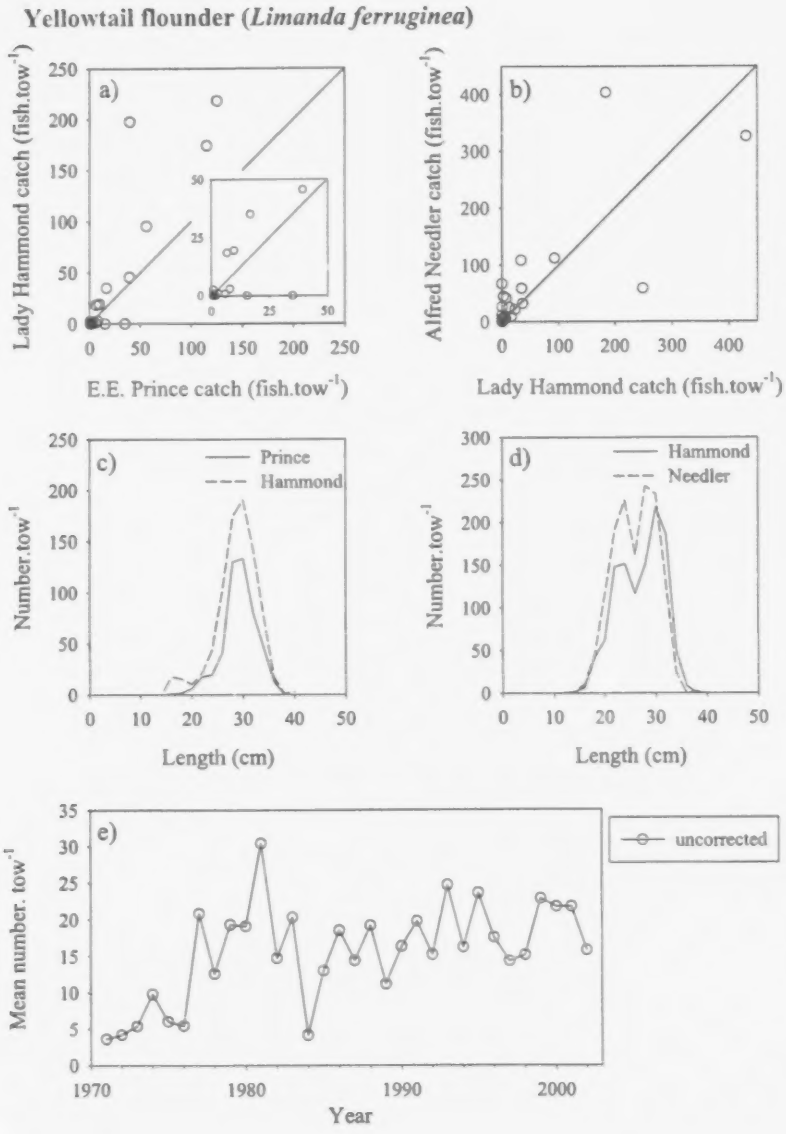

Figure 11. Yellowtail flounder catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for yellowtail flounder is presented in panel (e).

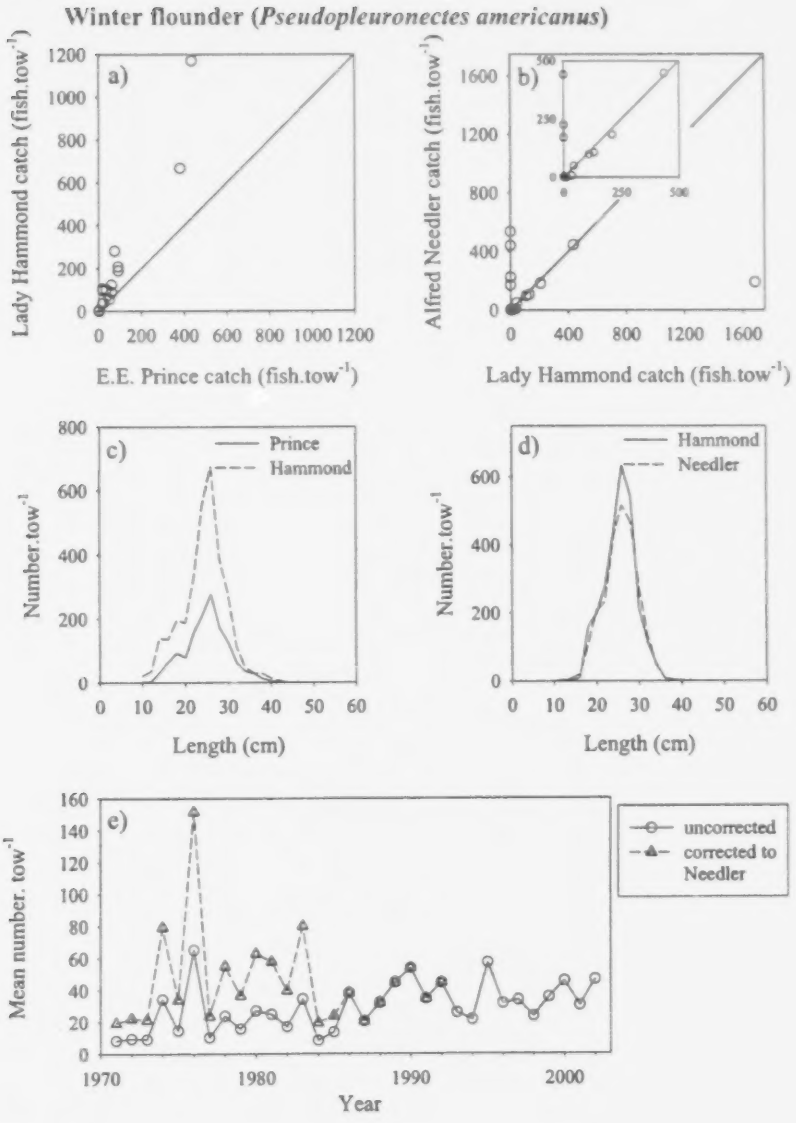

Figure 12. Winter flounder catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency between the *Lady Hammond* and the *E.E. Prince*.

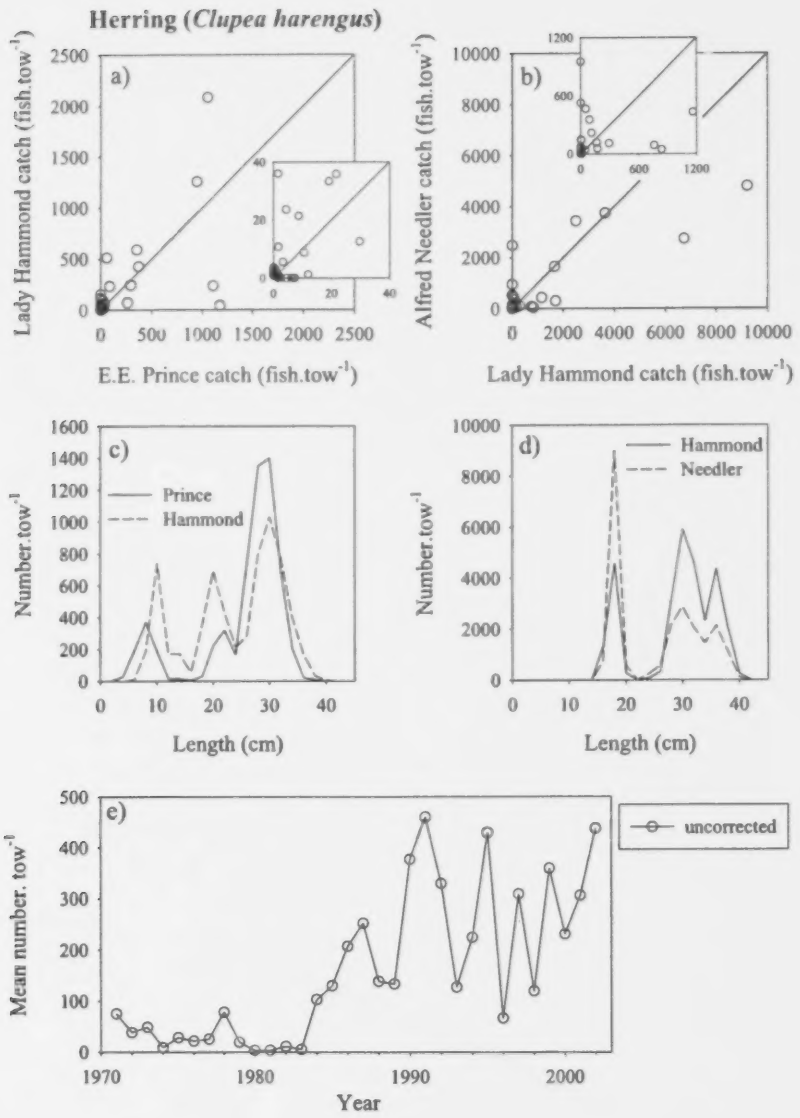

Figure 13. Herring catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for herring is presented in panel (e).

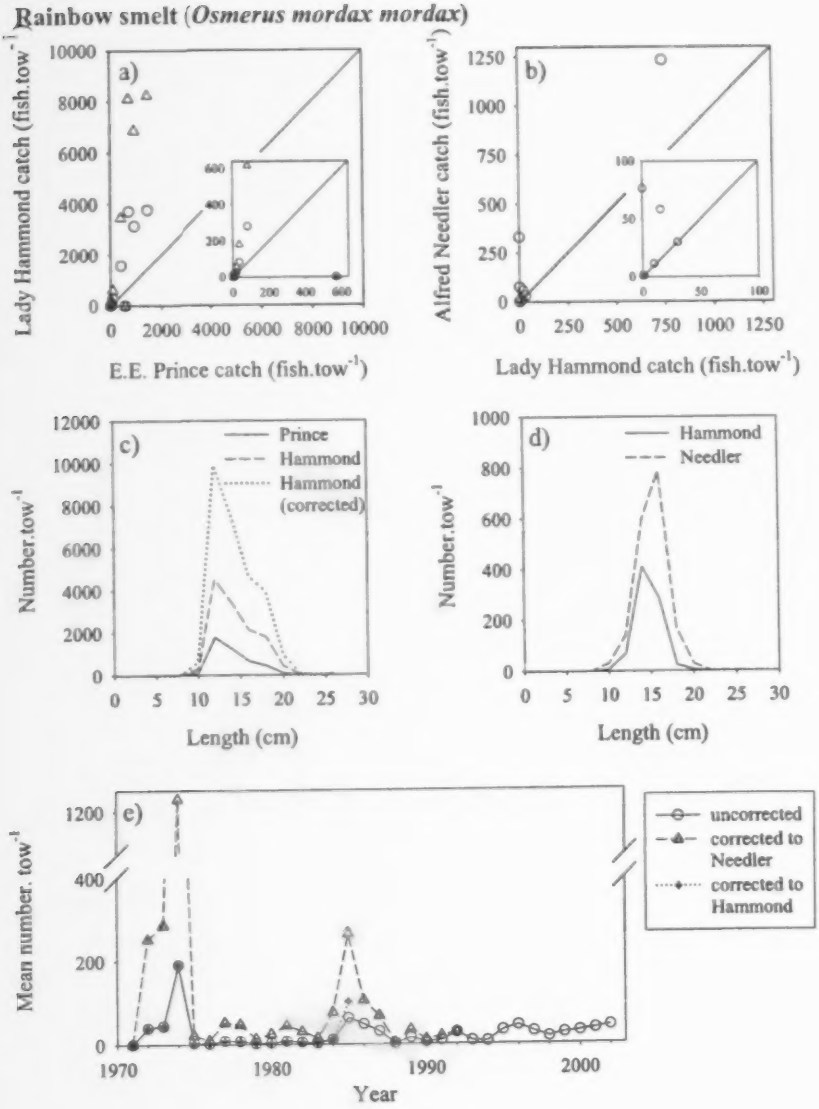

Figure 14. Rainbow smelt catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

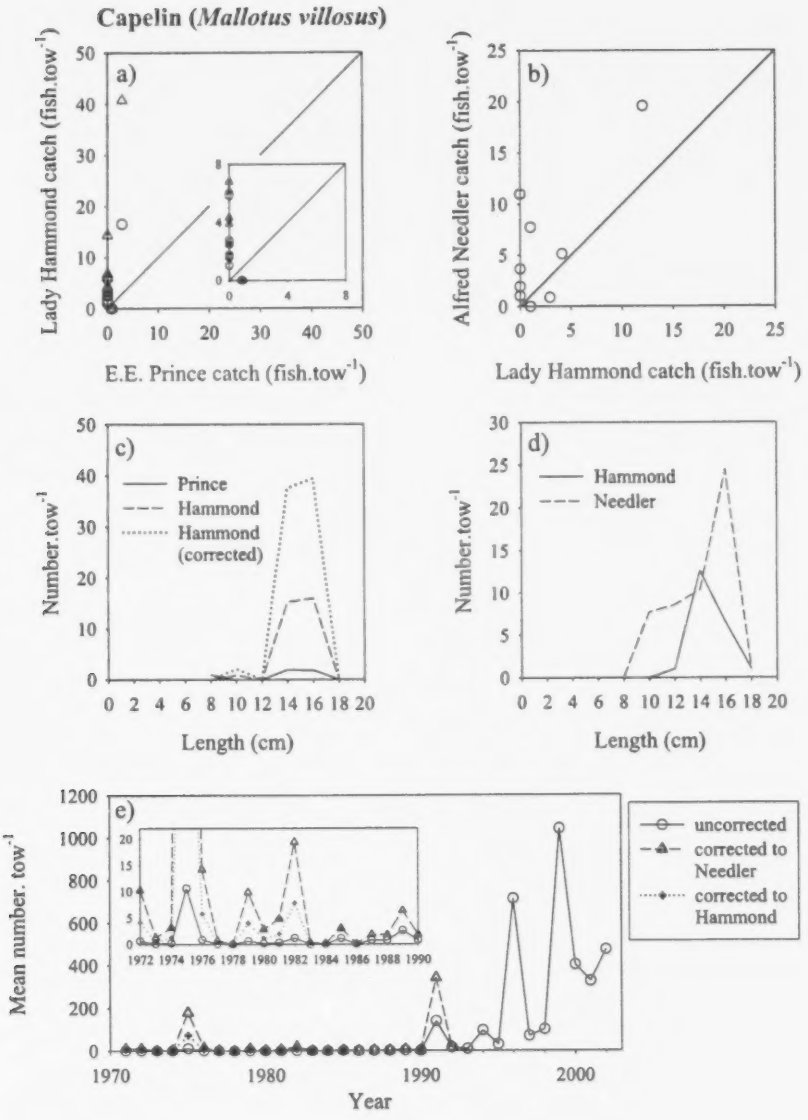

Figure 15. Capelin catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

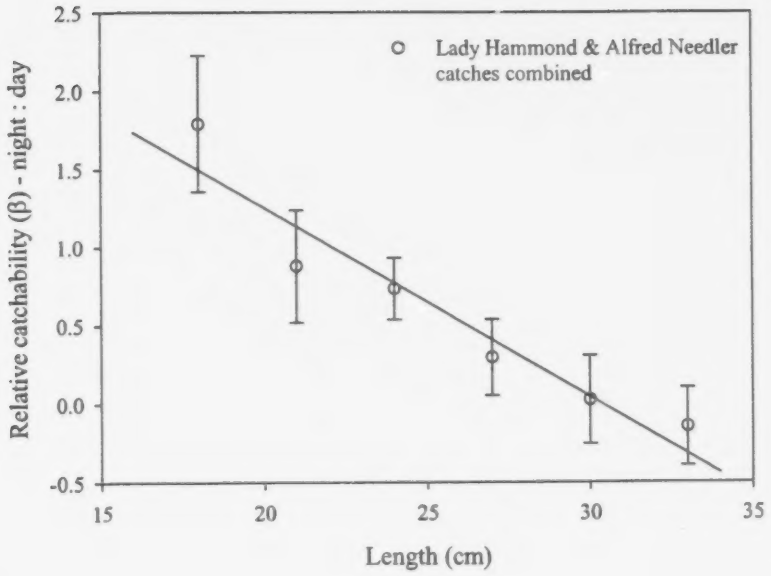

Figure 16. Diel differences in relative catchability ($\beta_d \pm$ SE) of long-fin hake as a function of body length. Catches by the *Lady Hammond* and the *Alfred Needler* were combined in the analysis in order to increase sample size. Length-dependent patterns were best described by a linear model (line) fit to the estimates from the combined vessel catches (see Table 1 and text for details).

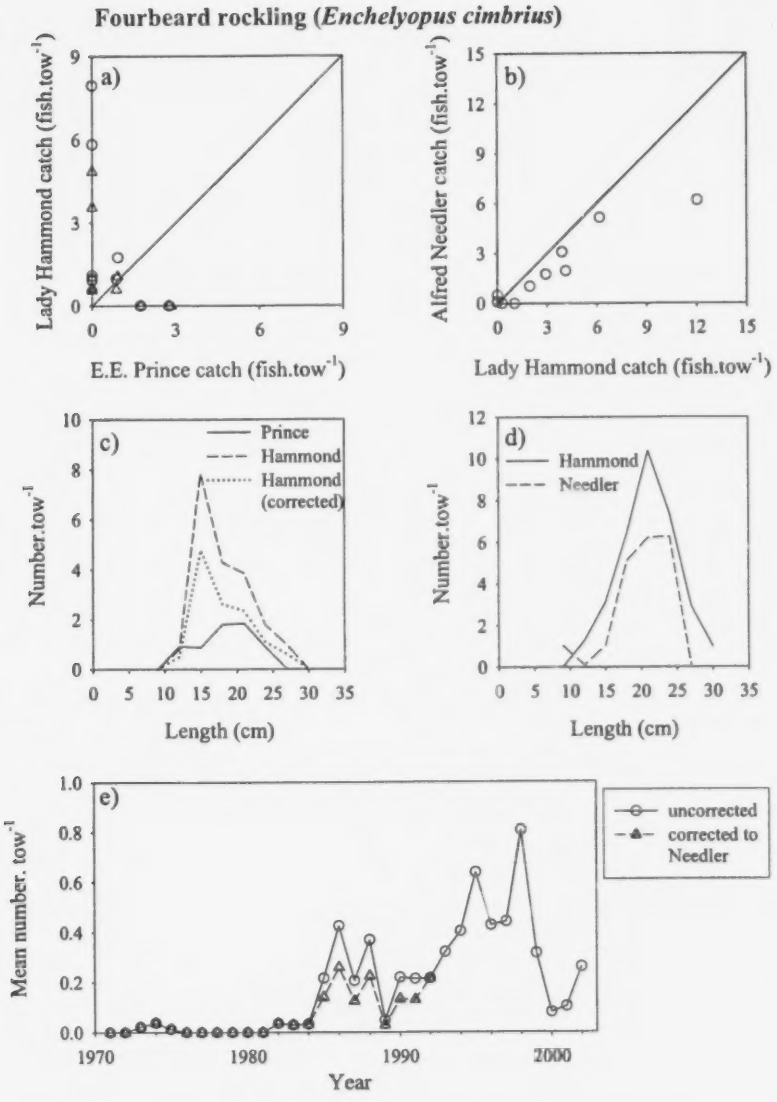

Figure 17. Fourbeard rockling catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

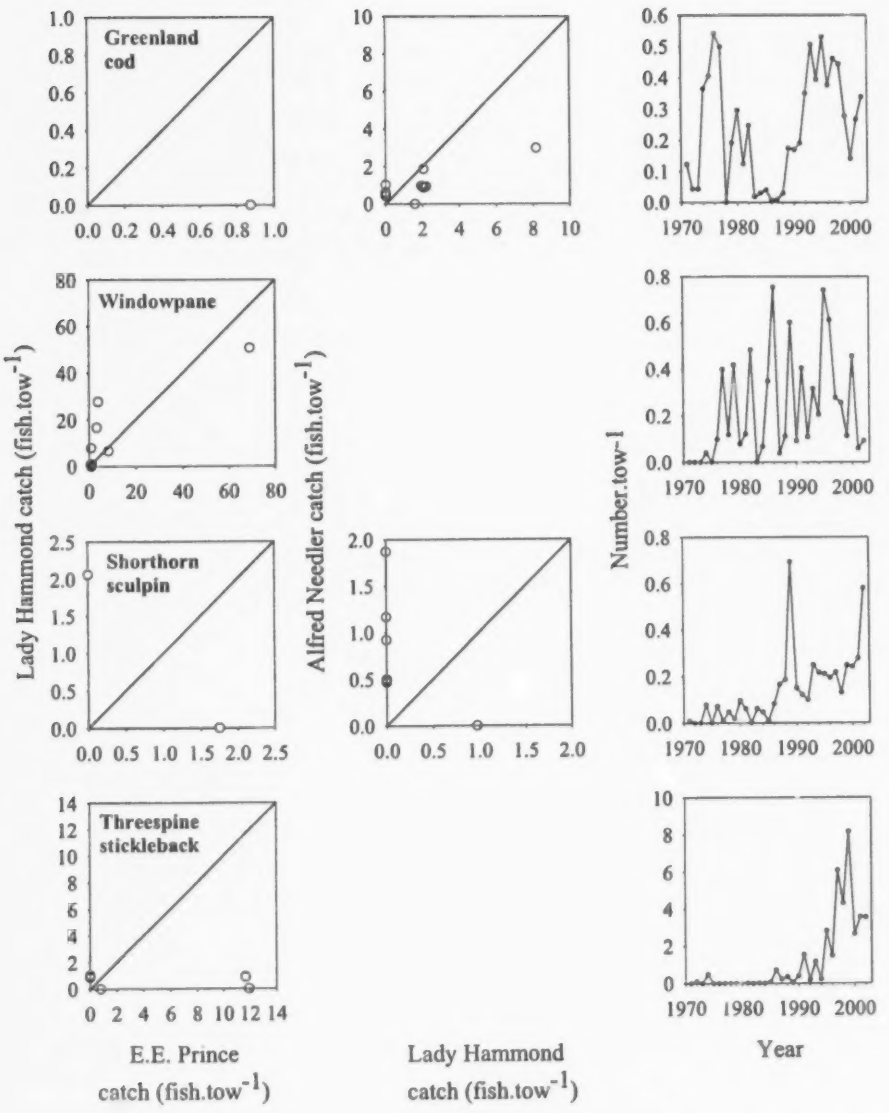

Figure 18. Catches of Greenland cod, windowpane, shorthorn sculpin and threespine stickleback (rows 1-4 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. The abundance index time series (mean numbers·tow^{-1}) for the respective species are presented in the rightmost column.

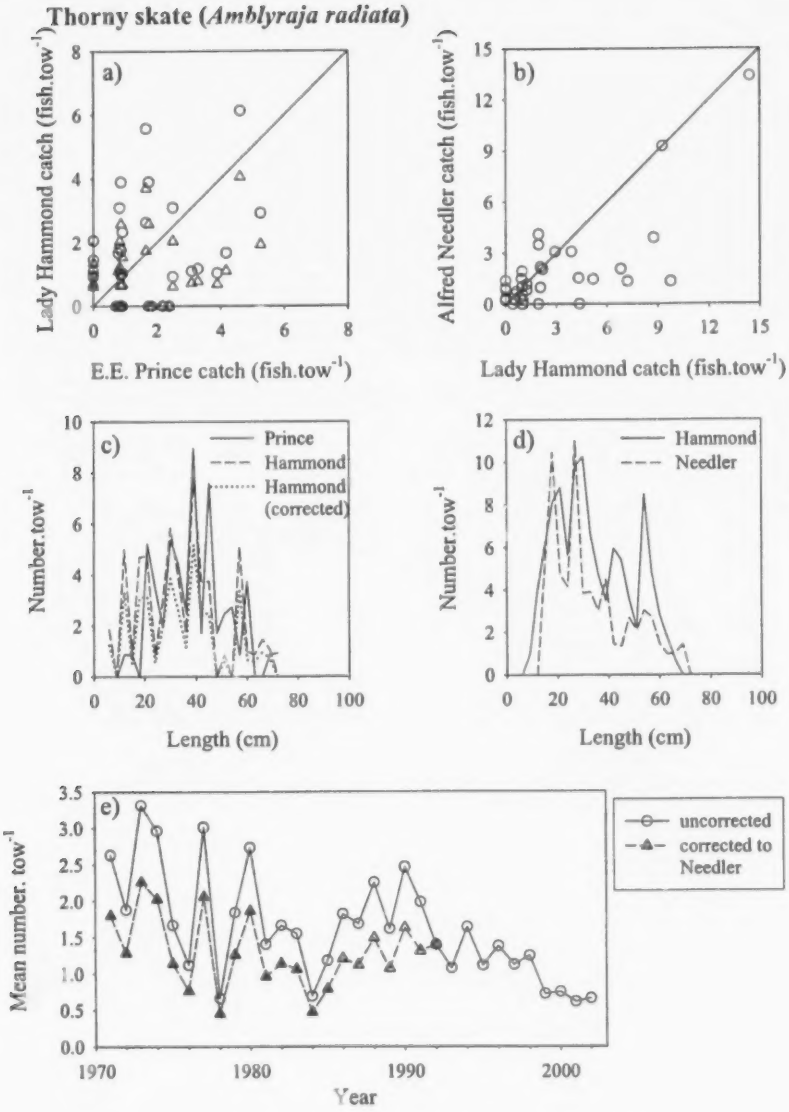

Figure 19. Thorny skate catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

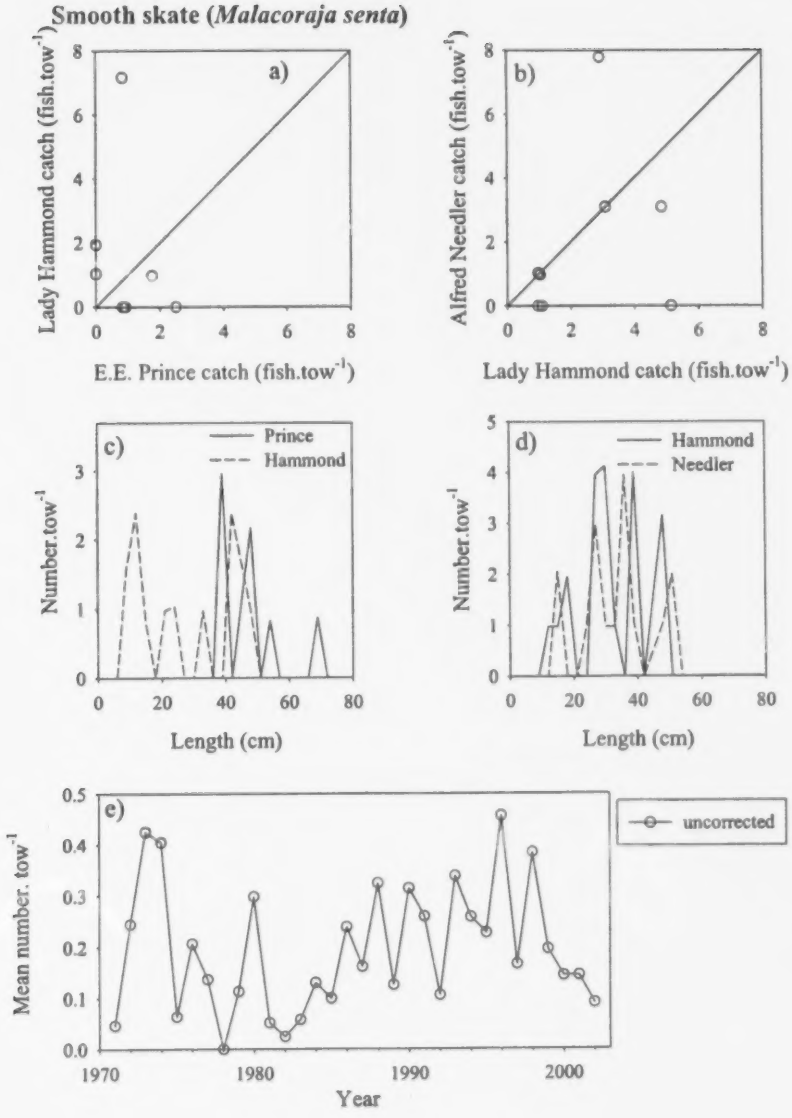

Figure 20. Smooth skate catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

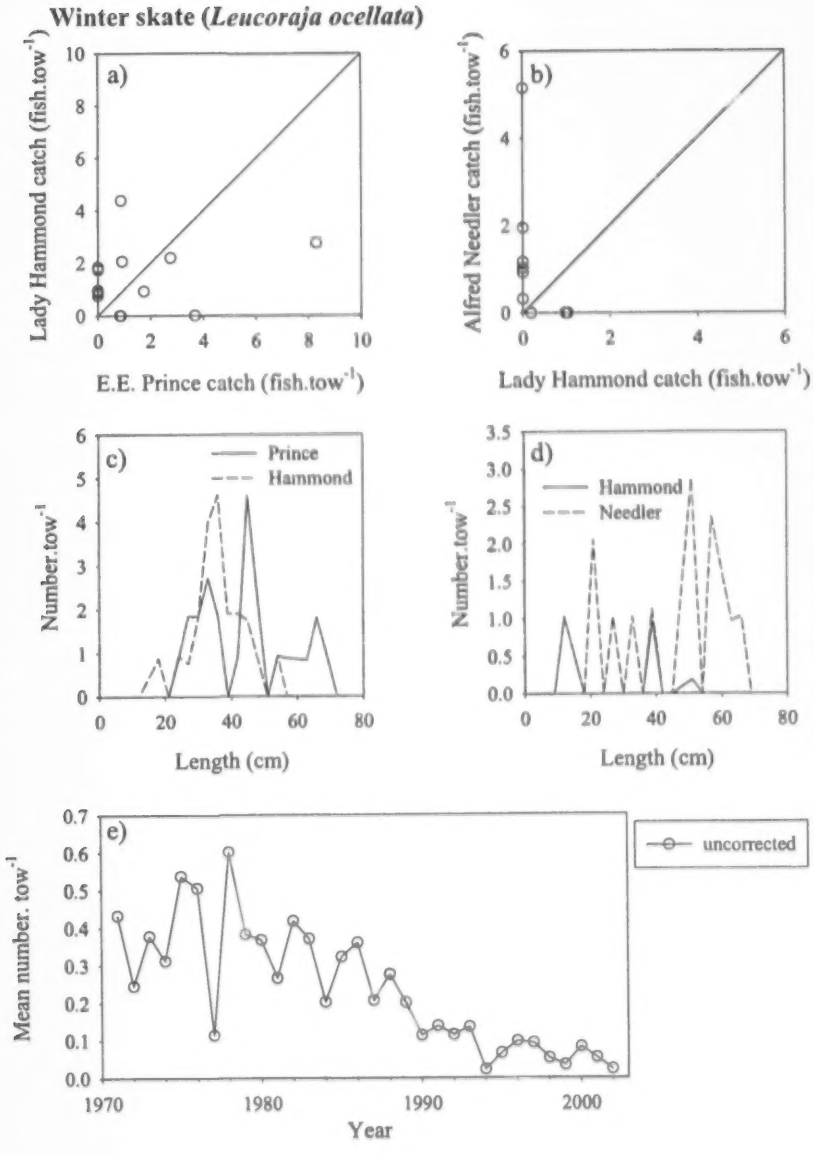

Figure 21. Winter skate catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

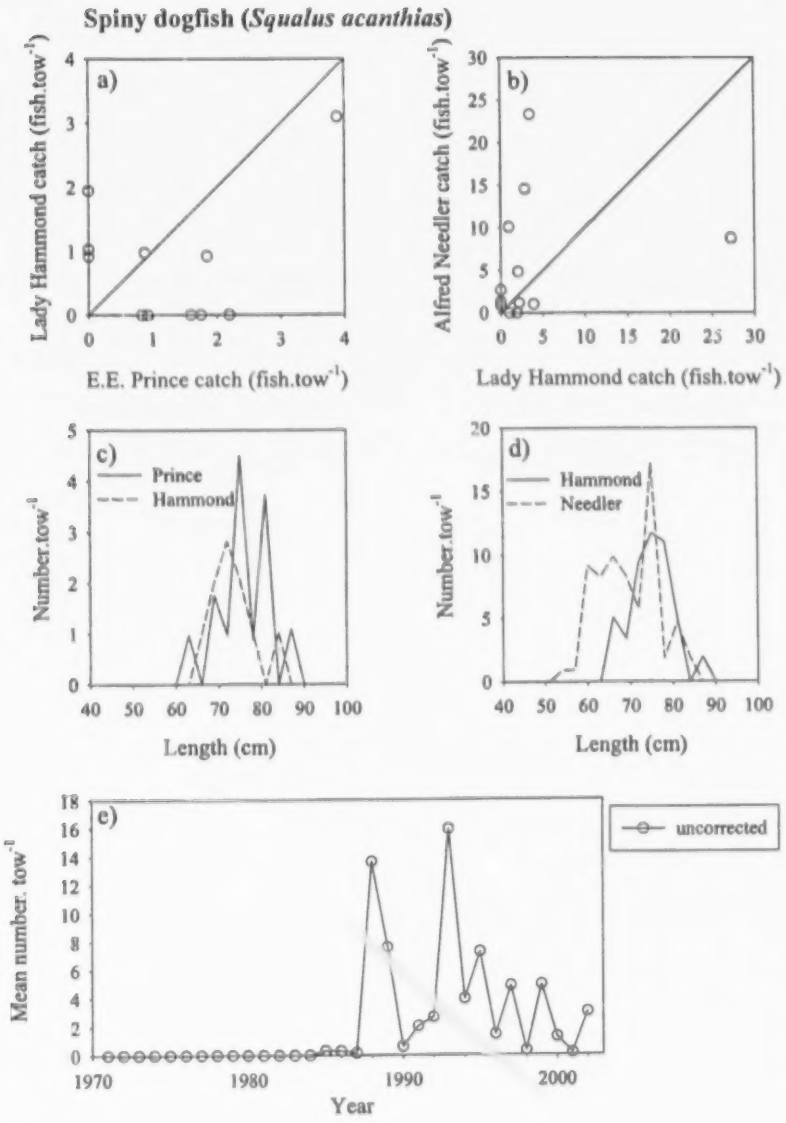

Figure 22. Spiny dogfish catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

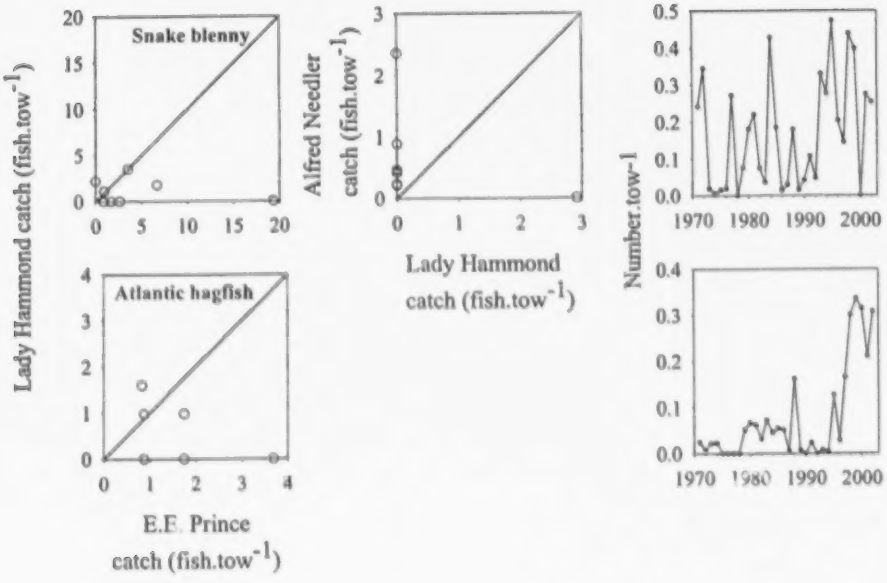

Figure 23. Catches of snakeblenny and hagfish (rows 1 and 2 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. The abundance index time series (mean numbers·tow^{-1}) for the respective species are presented in the rightmost column.

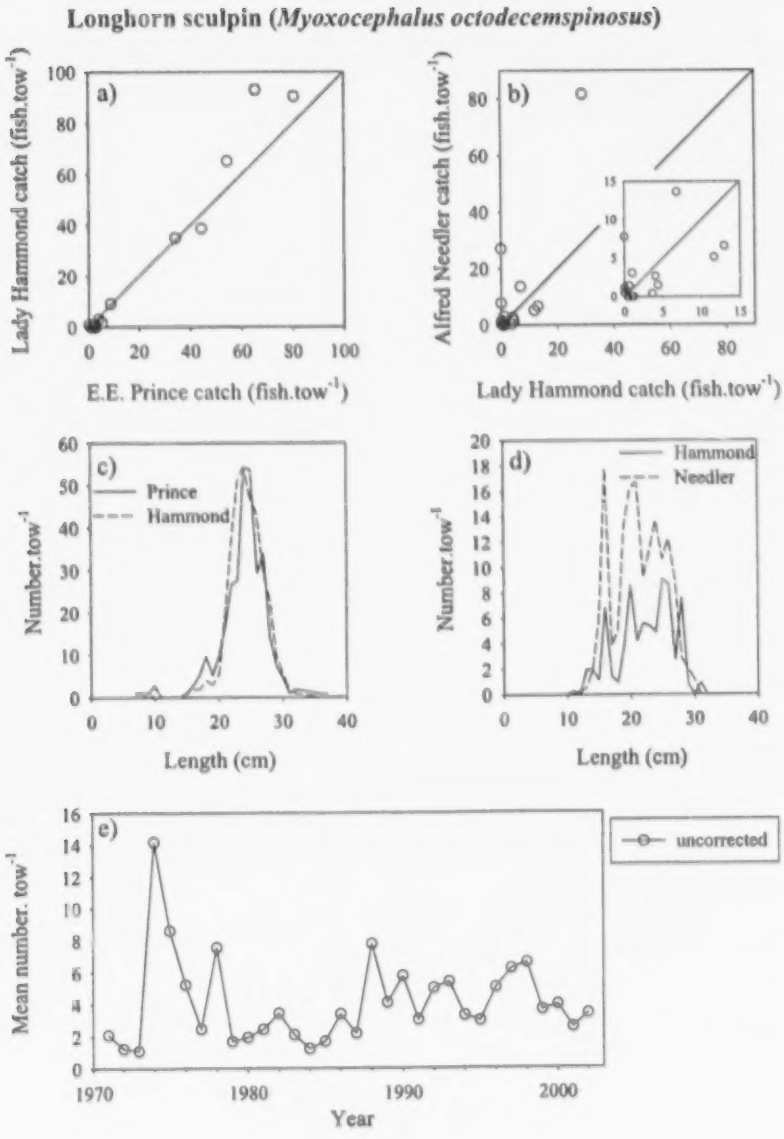

Figure 24. Longhorn sculpin catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

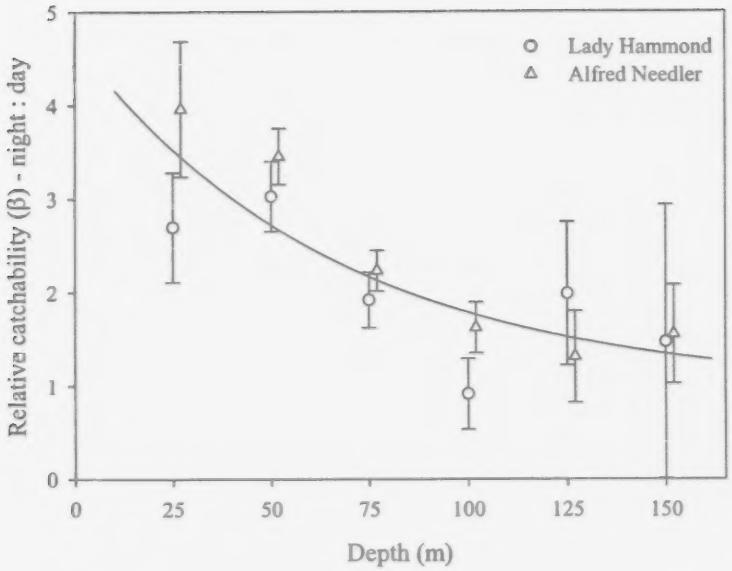

Figure 25. Diel differences in relative catchability ($\beta_d \pm$ SE) of mailed sculpin as a function of fishing depth, for catches by the *Lady Hammond* and the *Alfred Needler*. Depth-dependent patterns were best described by an exponential decay model (line) fit to the estimates from both vessels (see Table 1 and text for details).

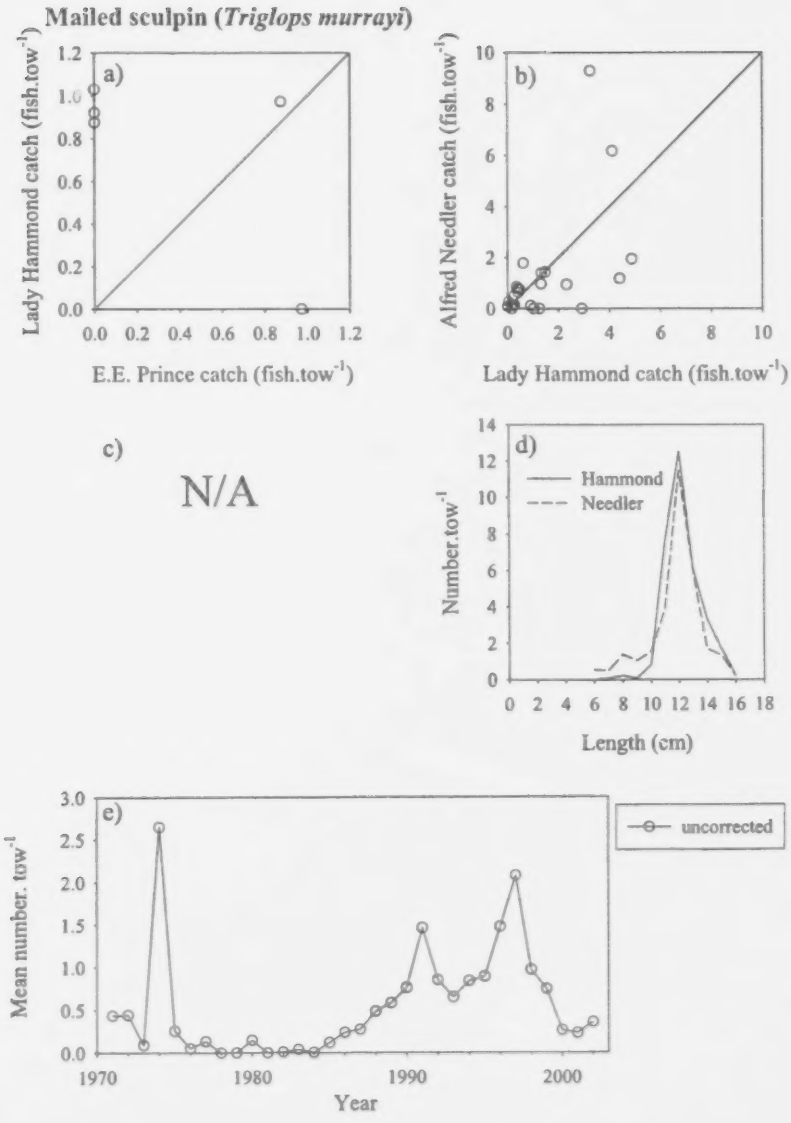

Figure 26. Mailed sculpin catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from the 1992 surveys are presented in (d). Length frequencies for the 1985 comparative surveys are not presented given the small number of individuals captured. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

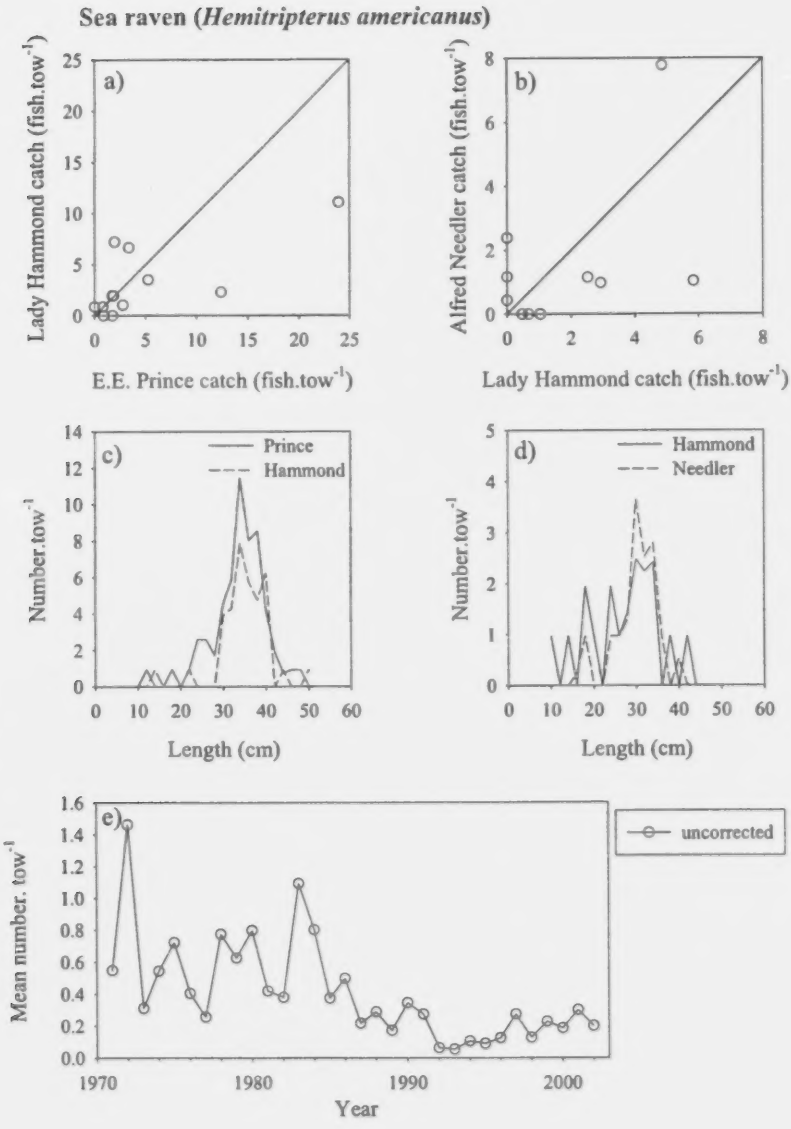

Figure 27. Sea raven catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

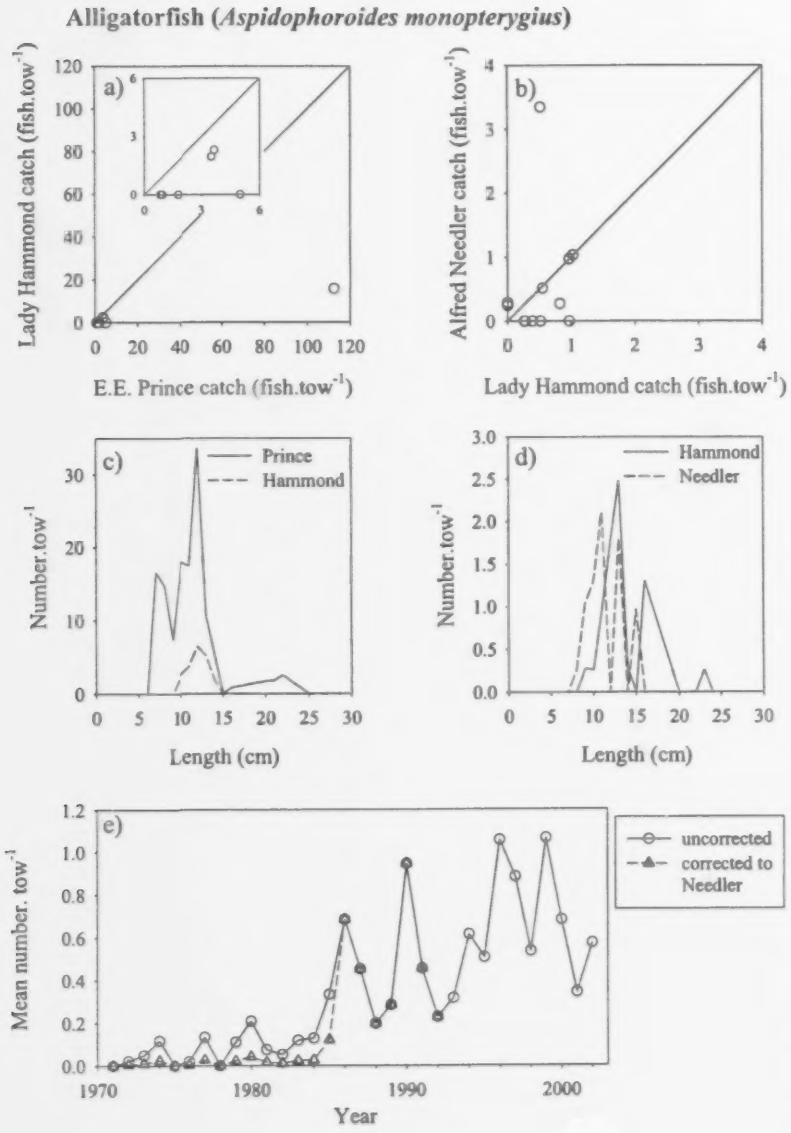

Figure 28. Alligatorfish catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency between the *Lady Hammond* and the *E.E. Prince*.

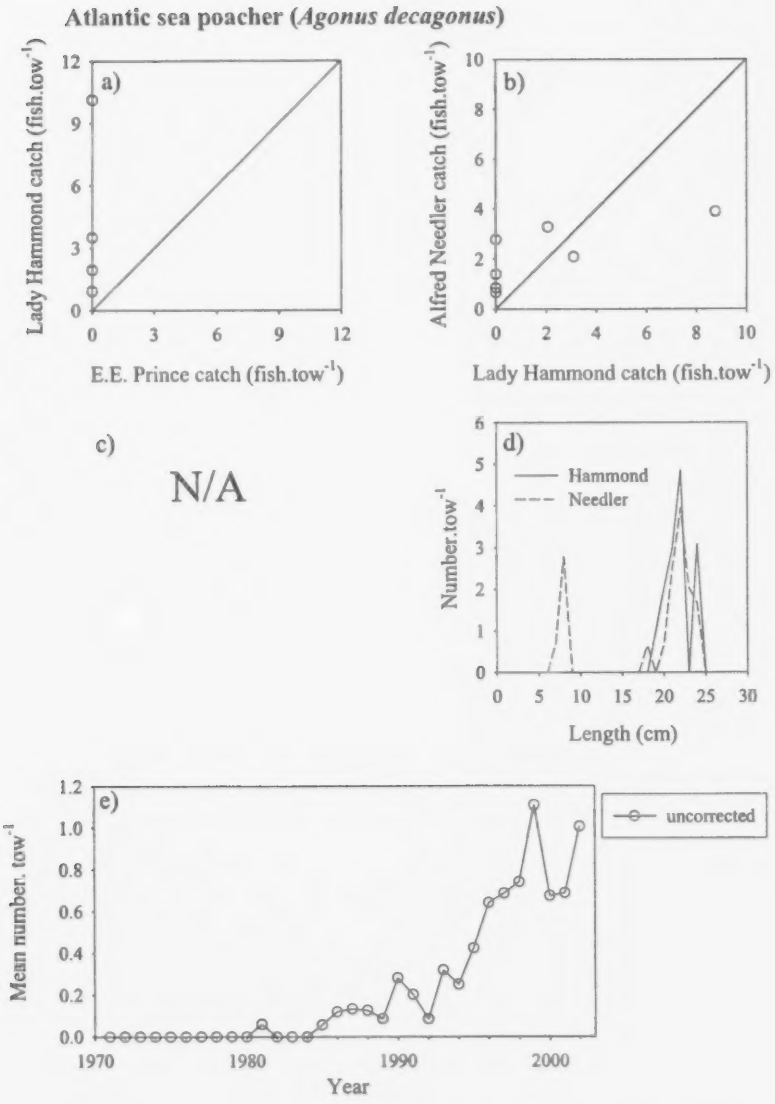

Figure 29. Atlantic sea poacher catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from the 1992 surveys are presented in (d). Length frequencies for the 1985 comparative surveys are not presented given the small number of individuals captured. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

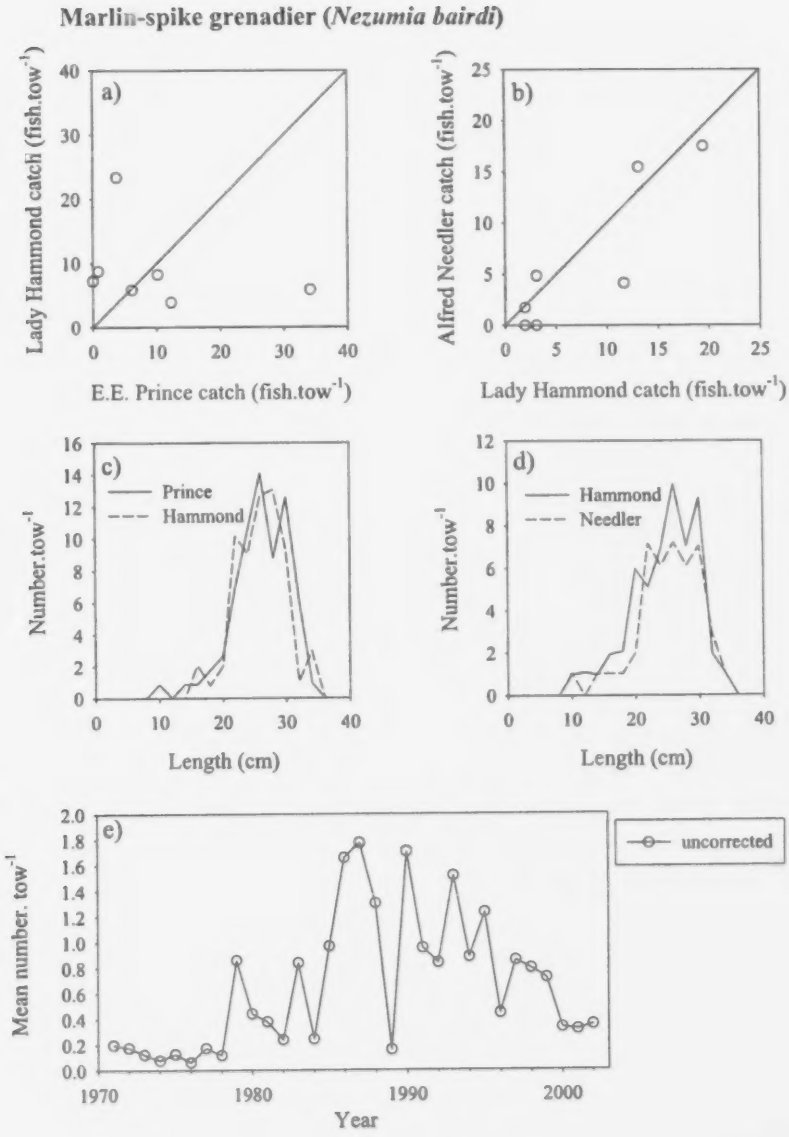

Figure 30. Marlin-spike grenadier catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

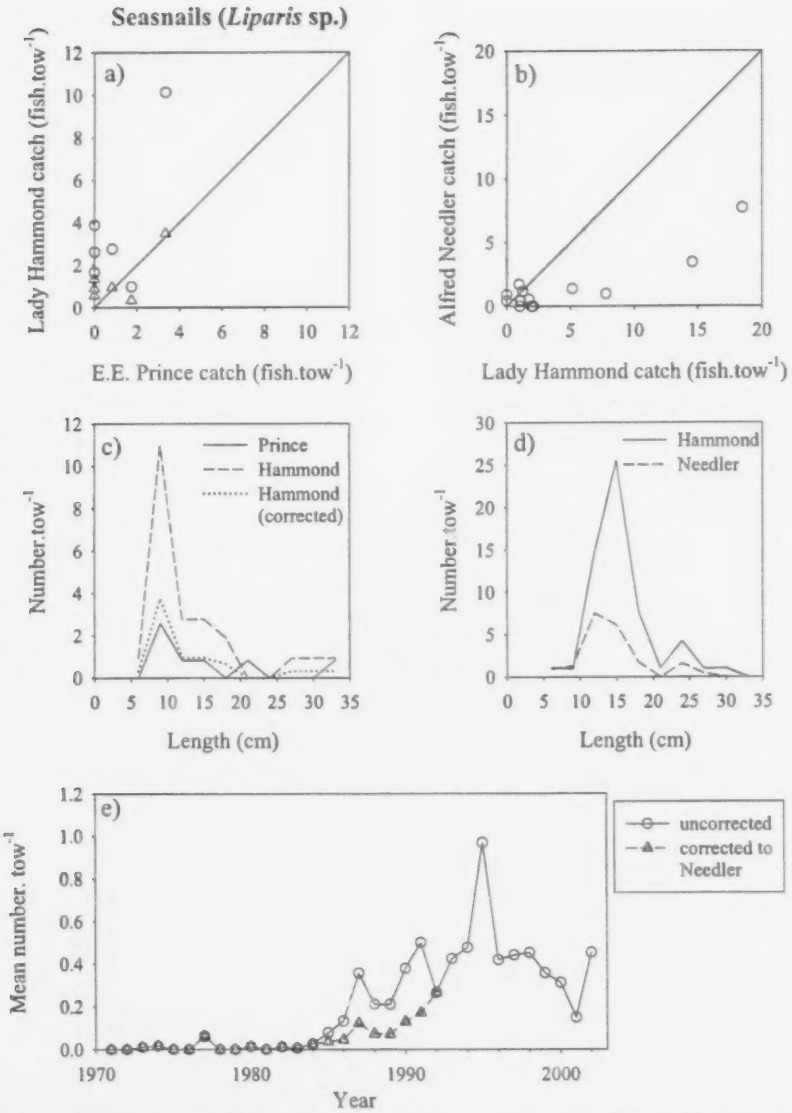

Figure 31. Seasnail catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

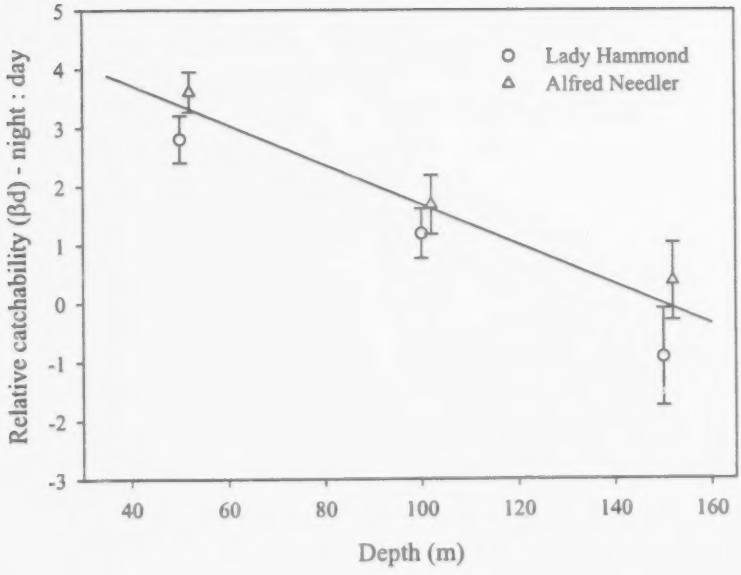

Figure 32. Diel differences in relative catchability ($\beta_d \pm$ SE) of fourline snakeblenny as a function of fishing depth, for catches by the *Lady Hammond* and the *Alfred Needler*. Depth-dependent patterns were best described by a linear model (line) fit to the estimates from both vessels (see Table 1 and text for details).

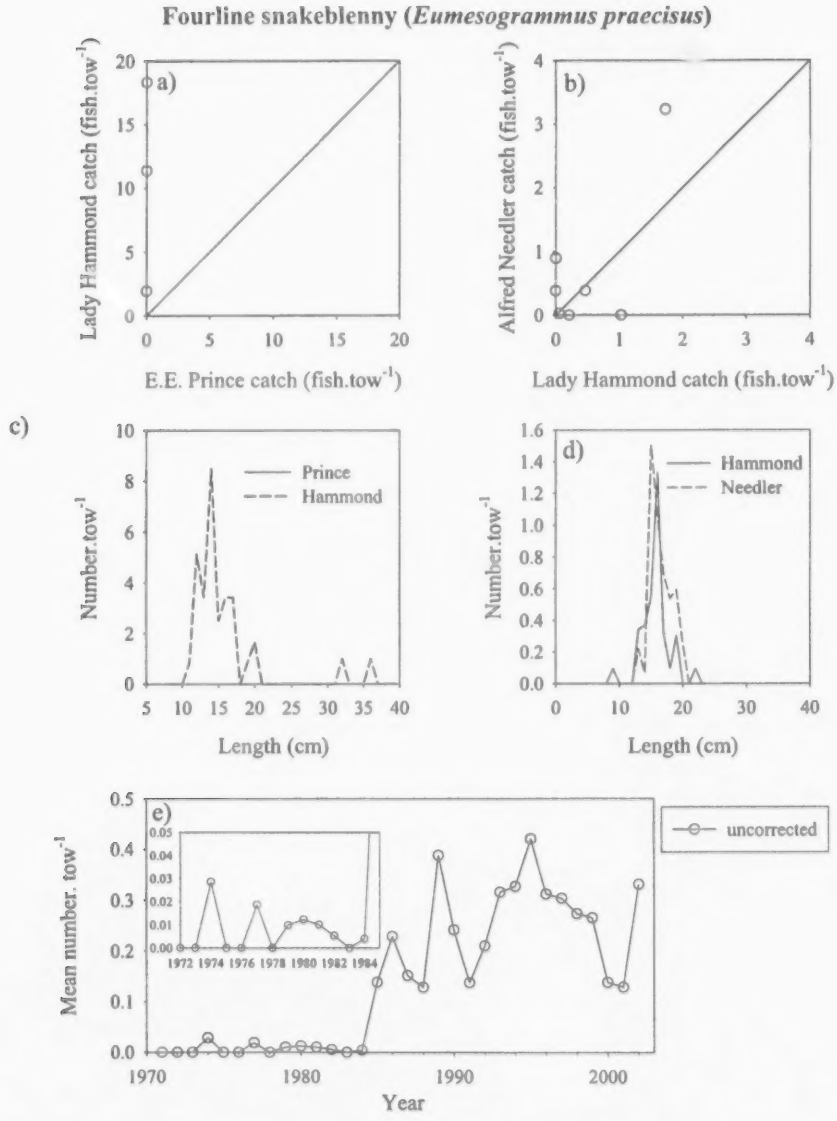

Figure 33. Fourline snakeblenny catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. The abundance index time series (mean numbers·tow^{-1}) for this species is presented in panel (e).

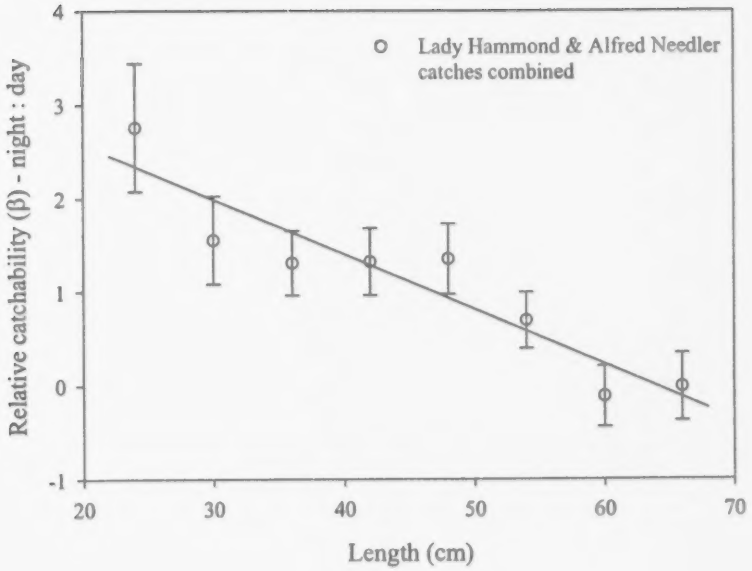

Figure 34. Diel differences in relative catchability ($\beta_d \pm$ SE) of ocean pout as a function of body length. Catches by the *Lady Hammond* and the *Alfred Needler* were combined in the analysis in order to increase sample size. Length-dependent patterns were best described by a linear model (line) fit to the estimates from the combined vessel catches (see Table 1 and text for details).

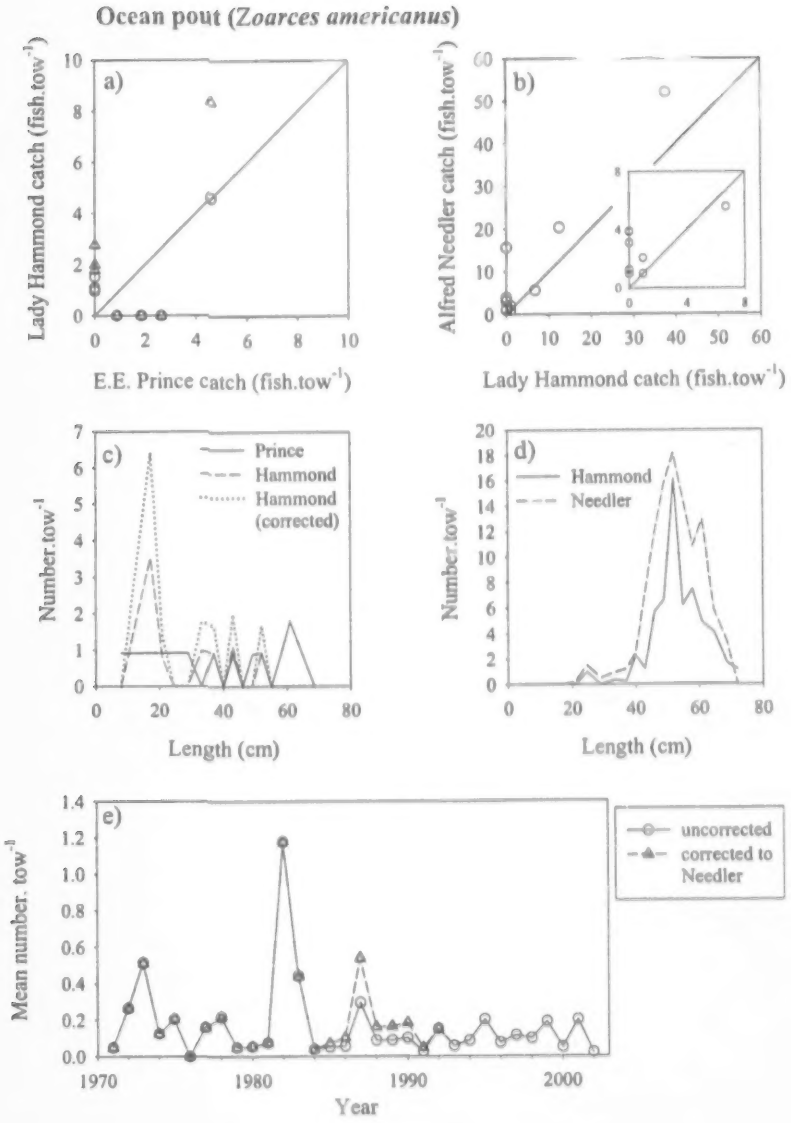

Figure 35. Ocean pout catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

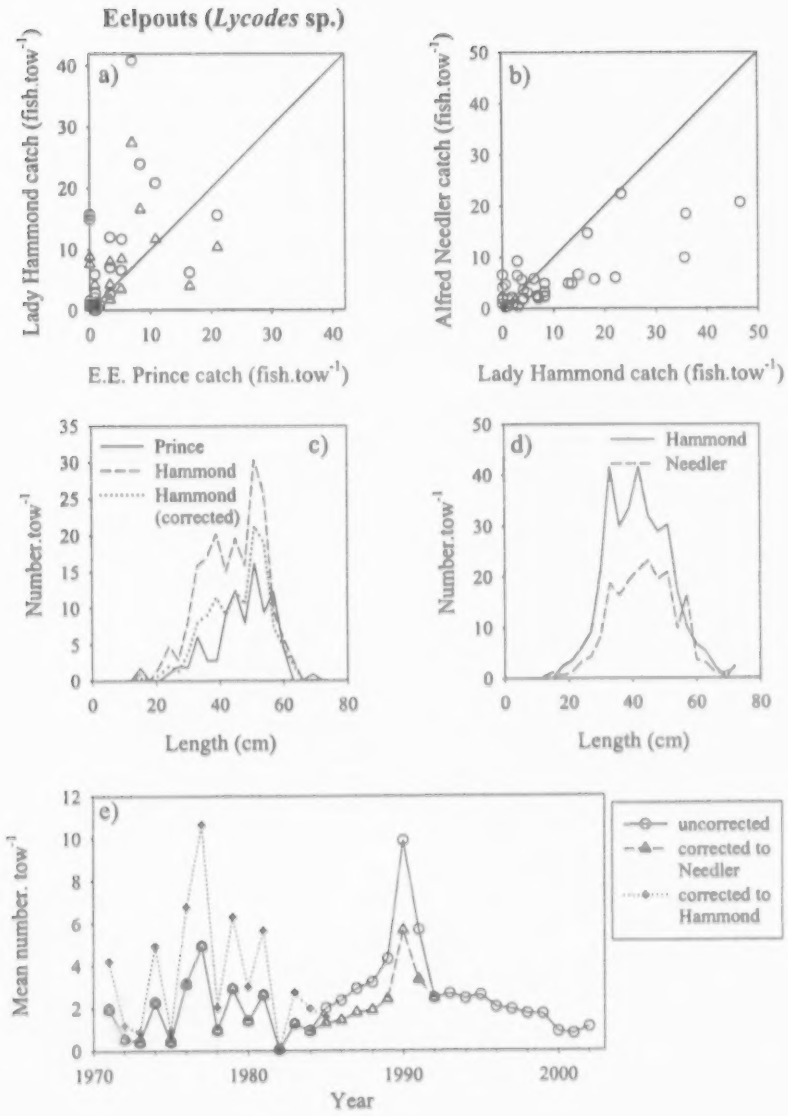

Figure 36. Eelpout catches in the (a) 1985 and (b) 1992 comparative surveys, with 1:1 lines added for comparison. The length frequencies from these surveys are presented in (c) and (d) respectively. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond*, the graphs for the 1985 survey (panels a, c) are presented using both corrected and uncorrected *Lady Hammond* catches. Abundance index time series (mean numbers·tow^{-1}) are presented in panel (e), for uncorrected catches and catches corrected for significant differences in vessel fishing efficiency.

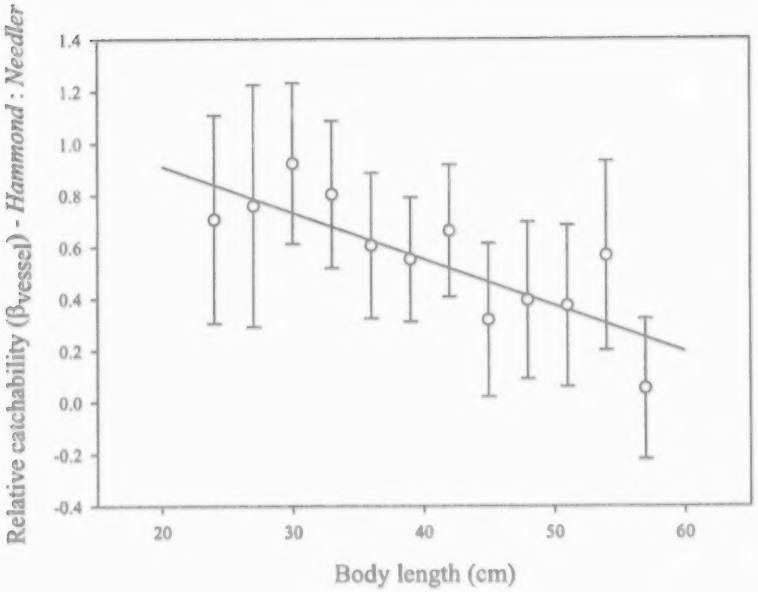

Figure 37. Relative efficiency ($\beta_v \pm$ SE) of the *Alfred Needler* and the *Lady Hammond* at capturing eelpouts as a function of body length. Length-dependent patterns were best described by a linear model (line) fit to the individual estimates (see Table 2 and text for details).

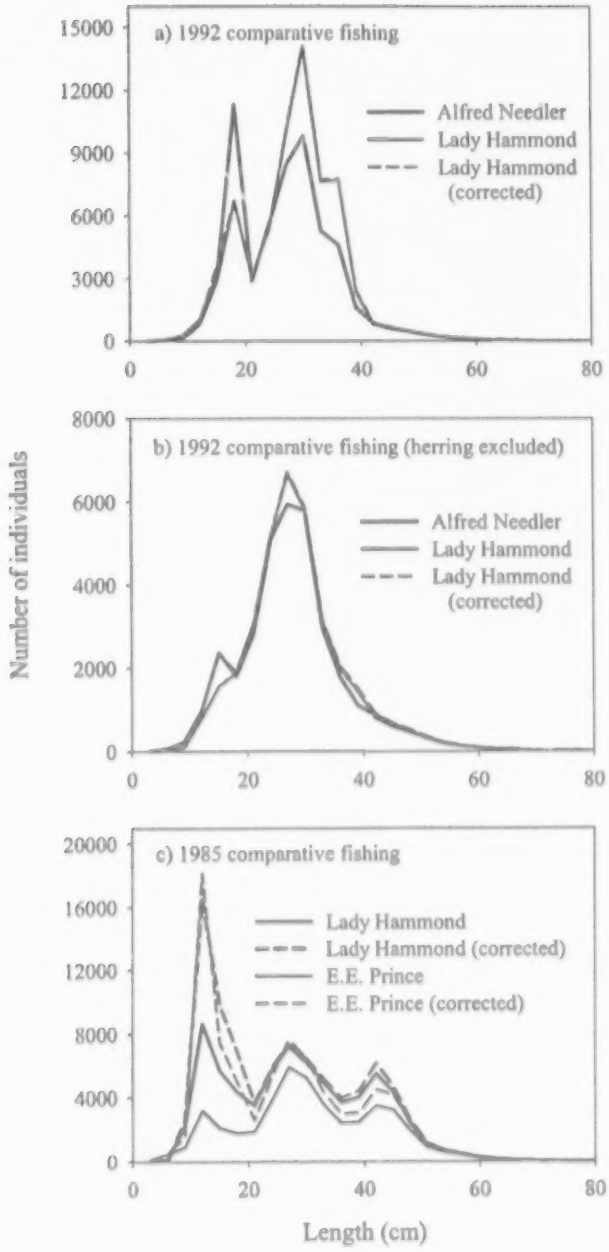

Figure 38. Total length frequencies for all fish species combined during the comparative fishing experiments in (a) 1992, (b) 1992 (excluding herring catches) and (c) 1985. Length frequencies are presented for both uncorrected catches and catches adjusted based on the results of the comparative fishing.

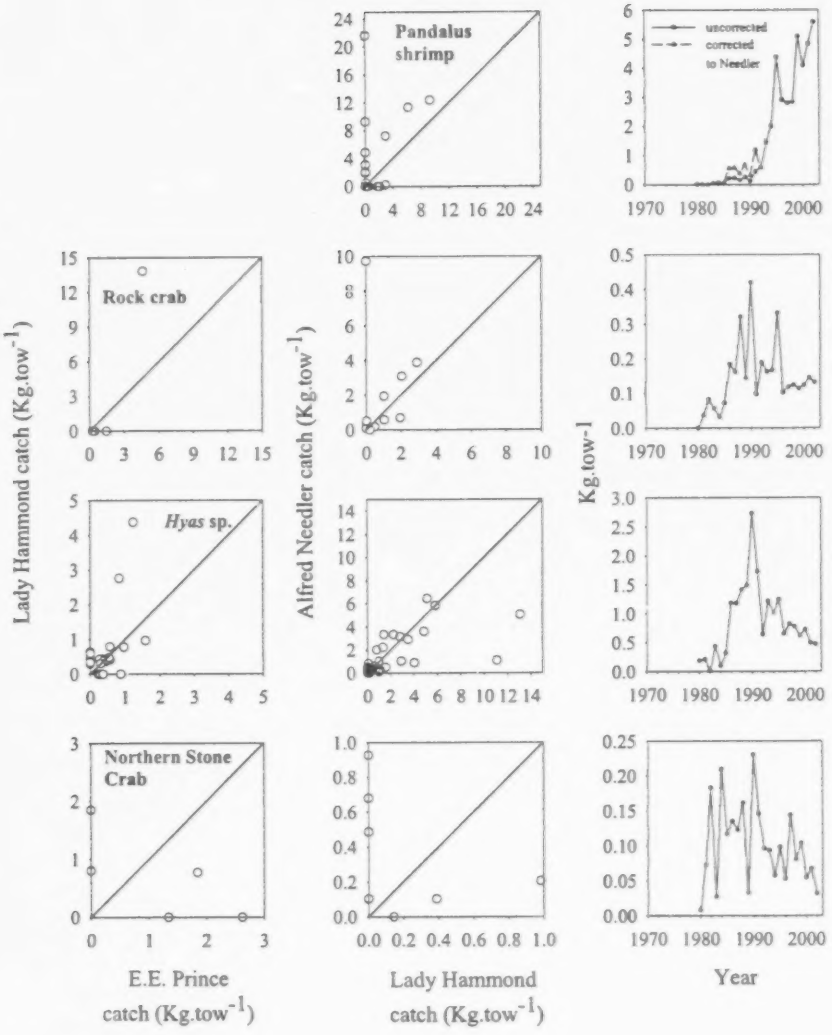

Figure 39. Catches of Pandalus shrimp, rock crab, *Hyas* sp. crabs and northern stone crab (rows 1-4 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. The abundance index time series (mean kg·tow^{-1}) for the respective species are presented in the rightmost column.

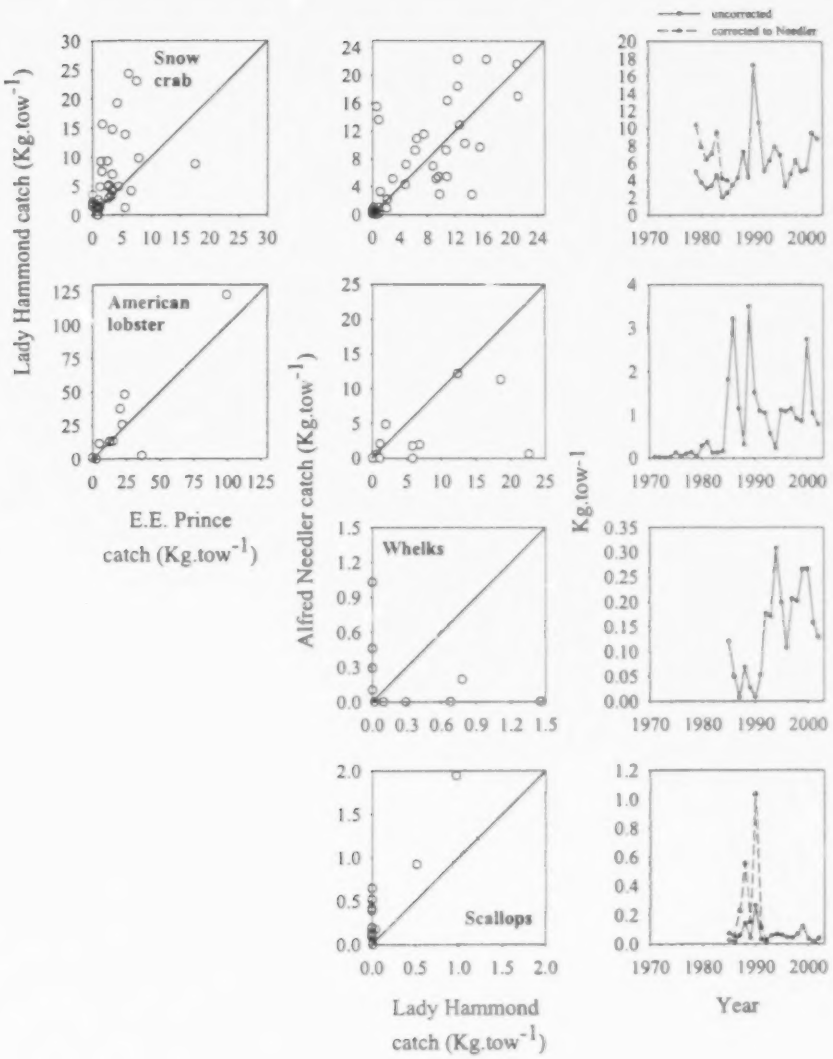

Figure 40. Catches of snow crab, American lobster, whelks and scallops (rows 1-4 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. The abundance index time series (mean kg·tow^{-1}) for the respective species are presented in the rightmost column.

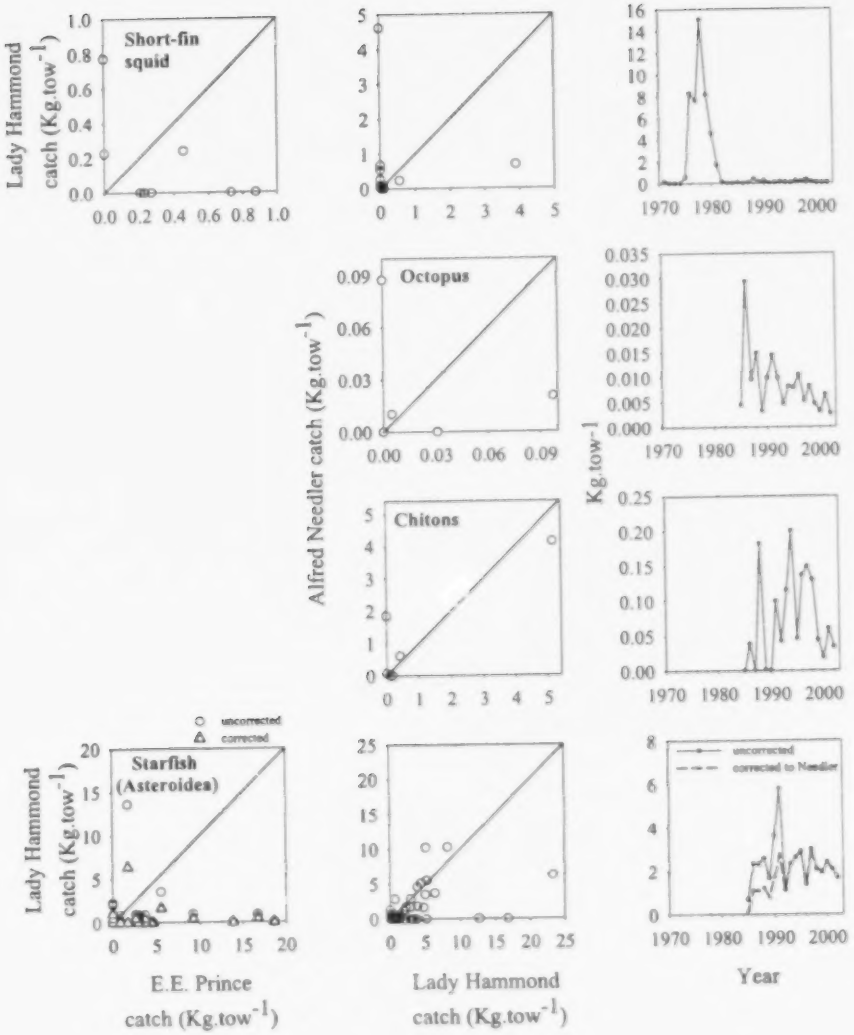

Figure 41. Catches of short-fin squid, octopus, chitons and starfish (rows 1-4 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. Given the significant difference in fishing efficiency between the *Alfred Needler* and the *Lady Hammond* when catching starfish, the graph for the 1985 survey for this species is presented using both corrected and uncorrected *Lady Hammond* catches. The abundance index time series (mean kg·tow^{-1}) for the respective species are presented in the rightmost column.

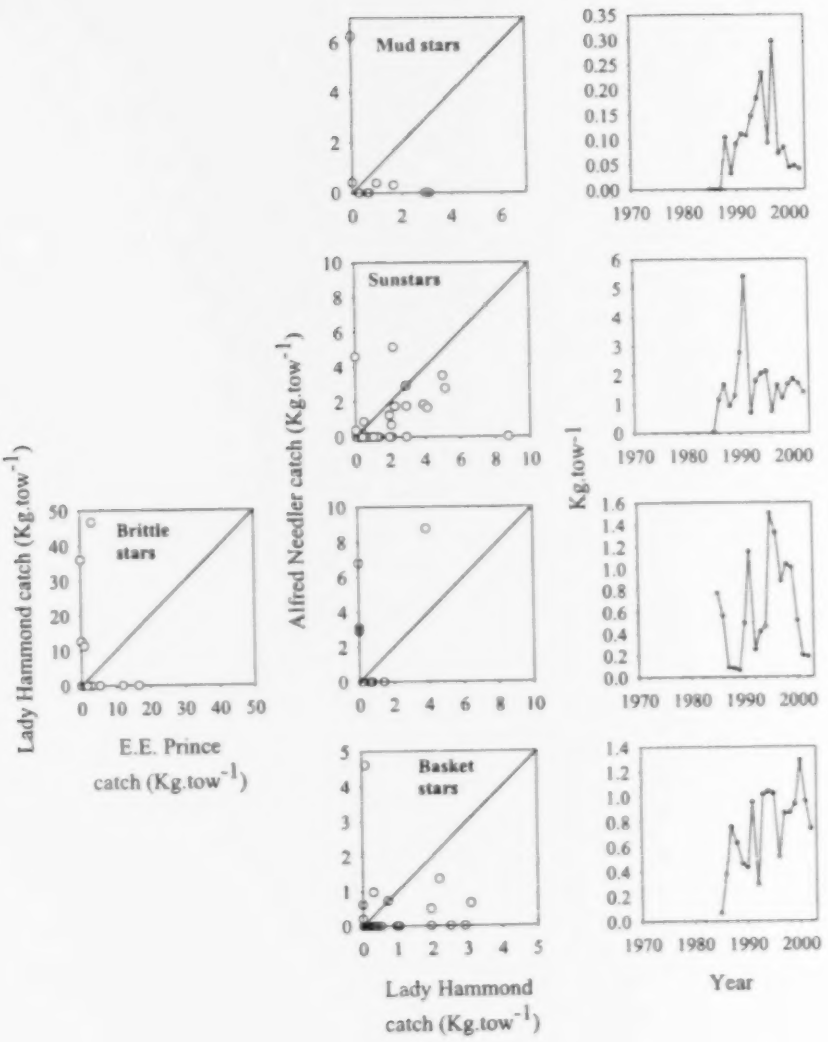

Figure 42. Catches of mud stars, sunstars, brittle stars and basket stars (rows 1-4 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. The abundance index time series (mean kg·tow^{-1}) for the respective species are presented in the rightmost column.

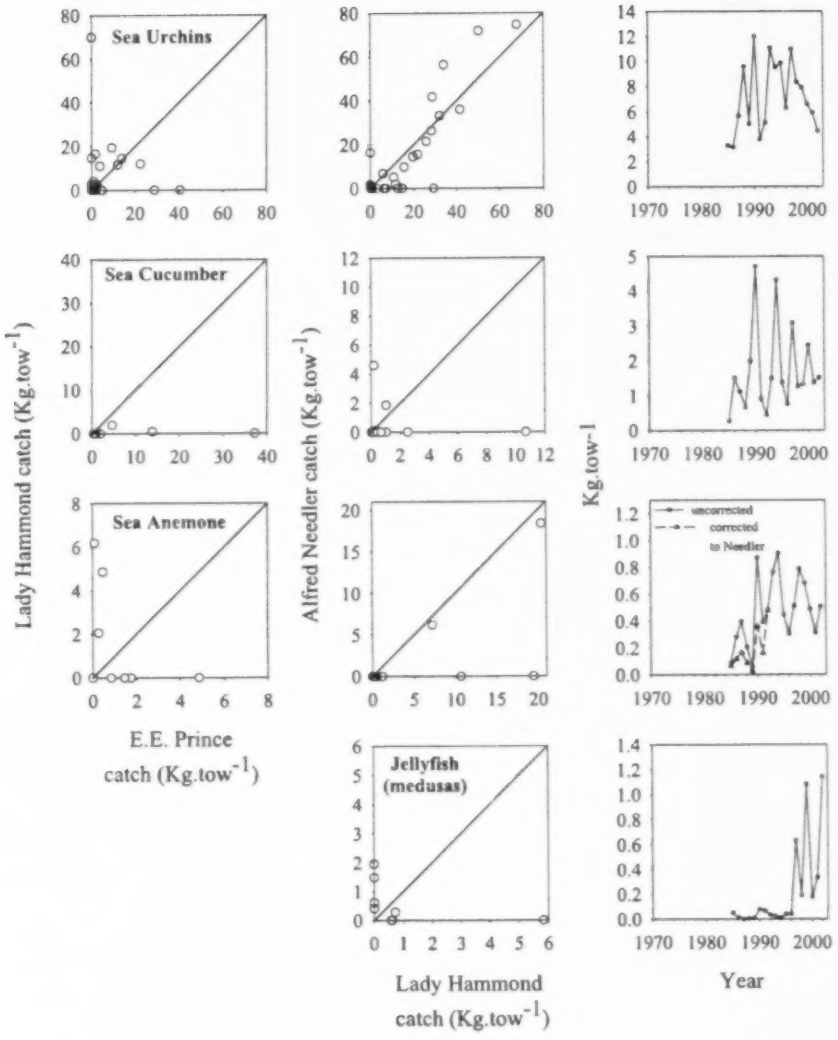

Figure 43. Catches of sea urchins, sea cucumber, sea anemones and jellyfish medusas (rows 1-4 respectively) in the 1985 (left column) and 1992 (middle column) comparative fishing surveys, with 1:1 lines added for comparison. The abundance index time series (mean kg·tow^{-1}) for the respective species are presented in the rightmost column.

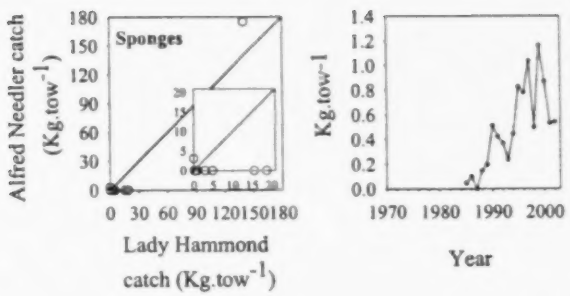

Figure 44. Catches of sponges in the 1992 comparative fishing surveys (left column), with a 1:1 line added for comparison. The abundance index time series (mean kg·tow^{-1}) for this species is presented in the rightmost column.